Original Article

Analysis of mast cells in dental follicle and dentigerous cyst: A histopathological study

Jayaraman Sindhumati[1], Sanjai Karpagaselvi[2], Kumaraswamy Jayalakshmi[2], Papaiah Lokesh[2], Keshavaiah Roopavathi[2], Pandey Bhavna[3]

[1]Department of Oral Pathology and Microbiology, Rajiv Gandhi College of Dental Sciences and Research Centre, Cholanagar, Hebbal, R T Nagar Post, Bengaluru, Karnataka, [2]Department of Oral Pathology and Microbiology, Vydehi Institute of Dental Sciences and Research Centre, Nallurahalli, Whitefield, Bengaluru, Karnataka, [3]Senior Medical Writer, Pitchman Communications, Mumbai, India

Abstract

Introduction: Mast cells are large granular cells that arise from multipotent CD 34+ precursors in the bone marrow normally distributed throughout the connective tissues. Following activation of immunologic or nonimmunologic stimuli, mast cells release secretory granules which give the characteristic metachromatic appearance with toluidine blue stain. Release of numerous mediators on degranulation of mast cells plays an important role in the pathogenesis of odontogenic cysts.

Context: Odontogenic cysts, such as dentigerous cysts, arise due to the accumulation of fluid between the crown of an unerupted tooth and the reduced enamel epithelium. Dental follicles, which surround developing teeth, can also undergo cystic transformation. Mast cells activity might contribute to cyst expansion and bone resorption, highlighting their potential role in cystic pathology.

Aims: To study the presence of mast cells in the dental follicle and dentigerous cyst. To quantify the mast cells in the abovementioned subjects. To study the pattern of distribution of mast cell distribution in different zones of the study groups.

Settings and Design: This was histopathological study conducted at the Department of Oral Pathology and Microbiology, Vydehi College of Dental Sciences and Research Centre, Bengaluru, between 2012 and 2015.

Methods and Material: Our study was conducted in the Department of Oral Pathology and Microbiology at Vydehi College of Dental Sciences and Research Centre in the year 2012 to 2015. Histopathologically analyzed 30 cases each of dental follicle, and dentigerous cysts were taken and 4–5 micron sections were stained with toluidine blue. Counting of mast cells was done in three different zones which included subepithelial, intermediate, and deep zone. The results were tabulated and statistically analyzed.

Statistical Analysis Used: Kruskal–Wallis Chi-squared test.

Results: Both dental follicles and dentigerous cysts showed the presence of mast cells, and highest numbers of mast cells were seen in subepithelial zone followed by intermediate and deep zones. There was statistically significant relation in the number of mast cells in dentigerous cysts and dental follicle

Address for correspondence: Dr. Jayaraman Sindhumati, Department of Oral Pathology and Microbiology, Rajiv Gandhi College of Dental Sciences and Research Centre, Cholanagar, Hebbal, R T Nagar Post, Bengaluru - 560 032, Karnataka, India.
E-mail: sindhumati@gmail.com

Submitted: 08-Nov-2023, **Revised:** 20-May-2024, **Accepted:** 11-Feb-2025, **Published:** 28-Mar-2025

Access this article online

Quick Response Code:

Website: https://journals.lww.com/JPAT/

DOI: 10.4103/jomfp.jomfp_479_23

How to cite this article: Sindhumati J, Karpagaselvi S, Jayalakshmi K, Lokesh P, Roopavathi K, Bhavna P. Analysis of mast cells in dental follicle and dentigerous cyst: A histopathological study. J Oral Maxillofac Pathol 2025;29:35-40.

along subepithelial and intermediate zone with a *P* value of <0.05. In our study, we also found increased mast cell count in inflamed cases of dental follicle and dentigerous cyst compared with noninflamed cases with a *P* value of <0.01.

Conclusions: It is well known that mast cells play a role in the initiation of inflammation, and this inflammatory process may be associated with pericoronal follicle enlargement, a process that could result in cystic transformation of the follicle. Hence, regular radiographic follow-up is necessary especially for teeth with a maximum dental follicle width of 2–3 mm.

Keywords: Dental follicle, dentigerous cyst, mast cells, toluidine blue

INTRODUCTION

Mast cells are innate immune cells, named by Paul Ehrlich in 1878 on the basis of their granular histological staining with aniline dyes.[1] These cells are round or oval in outline measuring about 12 to 15 micron meter in diameter, containing numerous basophilic granules in their cytoplasm.[2] Human mast cells originate from hematopoietic stem cells in the bone marrow, which give rise to common myeloid progenitors that can subsequently differentiate into mast cell precursors. It is also suggested that mast cells could arise from a shared basophil or mast cell progenitor.[1] In humans, there are three subsets of mast cells that have been characterized as[3]:

1. MCT, which expresses tryptase and resides primarily in the alveolar septa of the lung and in the small intestinal mucosa.
2. MCTC, which expresses tryptase, chymase, carboxypeptidase A (CPA), and cathepsin G and resides primarily in the skin and in the small intestinal submucosa.
3. MCc, which expresses chymase but lacks tryptase.

Mast cells are found in almost all major organs and vascularized tissues of the body.[4]

Following activation of immunologic or nonimmunologic stimuli, mast cells release secretory granules which give characteristic metachromatic appearance with toluidine blue stain.[5]

Release of numerous mediators on degranulation of mast cells plays an important role in the pathogenesis of odontogenic cysts.[6] They also play a role in the development of fibrotic conditions.[7] In addition to preformed granule contents, activated mast cells can also synthesize vasoactive mediators, for example, platelet activating factor, chemotactic mediators, and several proinflammatory cytokines such as IL-1, IL-3, IL-6, and TNF. Furthermore, mast cells are a rich source of heparin and proteolytic enzymes, such as tryptase, chymase and hyaluronic acid, which participate in connective tissue breakdown in the capsule during normal metabolic turnover, as well as in inflammation.[8]

Because of poor lymphatic drainage in the cyst wall,[6] breakdown products of connective tissue elements are extruded into the cystic lumen raising the hydrostatic pressure and leading to their enlargement. It has also been stated that mast cells may enhance bone resorption by heparin production.[9] Mast cells have also been regarded as the initiators of inflammation.[10]

The dental follicle (DF), a loose ectomesenchymally derived connective tissue surrounding the tooth germ, participates in tooth eruption and contributes extensively to the periodontium by producing osteoblasts, cementoblasts, and periodontal ligament cells (PDLCs) in tooth development.[11] Dental follicles are most frequently misdiagnosed entities.[12] Age-related morphological changes in dental follicles have been investigated for almost a century, in association with unerupted and impacted teeth[13] because of its potential to undergo cystic degeneration[14] and/or neoplastic transformation.[15] The dentigerous cyst is the most common odontogenic lesion associated with unerupted teeth, followed by keratocyst, odontomas, and ameloblastoma.[12]

The dentigerous cyst is a cystic lesion which arises when fluid or inflammatory exudates accumulate between the crown of an unerupted tooth and the reduced enamel epithelium.[16] The dentigerous cyst may be of either extra follicular or intrafollicular origin.[17]

The hydrostatic pressure of the luminal fluid is important in cyst enlargement and mast cell activity might contribute to this by increasing the osmotic pressure of the fluid in ways such as by direct release of heparin into the luminal fluid, by release of hydrolytic enzymes which could degrade capsular extracellular matrix components, thereby

facilitating their passage into the fluid and by the action of histamine on smooth muscle contraction and vascular permeability.[18] Mast cells are also implicated to stimulate production of prostaglandins which is considered important in bone resorption.[19] Tryptase also aid in bone resorption which is a feature in cyst enlargement at cyst bone interface.[8]

Hence, the purpose of the present study was to examine the role of mast cell activity in dental follicle and dentigerous cyst.

SUBJECTS AND METHODS

Study population consists of patients with impacted teeth and histopathologically diagnosed cases of dental follicle and dentigerous cyst reporting to the Department of Oral Medicine and Radiology, Department of Oral and Maxillofacial Surgery, and Department of Oral Pathology and Microbiology, Vydehi Institute of Dental Sciences and Research Centre, Bangalore. The study population consisted of histopathologically diagnosed, 30 cases each of dental follicle and dentigerous cyst and specimens that had undergone decalcification were excluded (as mast cell granules are obscured by this method).

- Paraffin blocks of cases were retrieved and sections varying from 4–5 micron in thickness was cut and stained with toluidine blue.
- Stained sections were analyzed under light microscopy.
- Counting was done in 3 different zones: subepithelial, intermediate, and deep.
- Subepithelial zone is the areas just beneath the epithelium. The next two consecutive microscopic fields are intermediate and deep zones.
- Randomly selected 10 areas under 10 X magnifications were considered.
- In each area, all 3 zones were considered.

RESULTS

Statistical Analysis

Both dental follicles and dentigerous cysts showed the presence of mast cells, and highest numbers of mast cells were seen in subepithelial zone followed by intermediate and deep zones. There was statistically significant relation in the number of mast cells in dentigerous cysts and dental follicle along subepithelial and intermediate zone with a *P* value of <0.05. In our study, we also found increased mast cell count in inflamed cases of dental follicle and dentigerous cyst compared with noninflamed cases with a *P* value of <0.01.

Table 1: Age distribution in the study sample

Age Group	Dental follicle		Dentigerous Cyst	
	n	%	*n*	%
<20 years	6	20%	7	23%
20-29 years	18	60%	9	30%
30-39 years	5	17%	6	20%
≥40 years	1	3%	8	27%
Total	30	100%	30	100%

Table 2: Sample distribution according to site of origin

Site	Dental follicle		Dentigerous cyst	
	n	%	*n*	%
Maxilla	3	10%	10	33%
Mandible	27	90%	20	67%
Total	30	100%	30	100%

Table 3: Gender distribution in the study sample

Lesion	Male		Female	
	n	%	*n*	%
Dental follicle	18	60%	12	40%
Dentigerous cyst	21	70%	9	30%
Total	39	100%	21	100%

Table 4: Comparison of mast cells within different layers in dental follicle

Layer	Mean	Std Dev	SE of Mean	95% CI for Mean		Kruskal–Wallis chi-square	*P*
				Lower Bound	Upper Bound		
Subepithelial	6.40	8.69	1.59	3.16	9.64	0.878	0.645
Intermediate	6.30	8.61	1.57	3.08	9.52		
Deep	6.07	11.76	2.15	1.67	10.46		

Table 5: Comparison of mast cells within different layers in dentigerous cyst

Layer	Mean	Std Dev	SE of Mean	95% CI for Mean		Kruskal–Wallis Chi-sq	*P*
				Lower Bound	Upper Bound		
Subepithelial	12.77	12.92	2.36	7.94	17.59	0.860	0.651
Intermediate	12.07	12.48	2.28	7.41	16.73		
Deep	10.60	13.71	2.50	5.48	15.72		

Table 6: Comparison of mast cells in subepithelial layer between dental follicle and dentigerous cyst

Lesion	Mean	Std Dev	SE of mean	Mean difference	*Z*	*P*
Dental follicle	6.40	8.69	1.59	-6.367	-2.043	0.041*
Dentigerous cyst	12.77	12.92	2.36			

DISCUSSION

Cysts of the jaws are probably the most common destructive bone lesions in the human maxillofacial skeleton. Odontogenic cysts are derived from the epithelium, which is associated with the development of the dental apparatus and can be either developmental or inflammatory in origin.[18] Mean eruption age of third

Table 7: Comparison of mast cells in intermediate layer between dental follicle and dentigerous cyst

Lesion	Mean	Std Dev	SE of Mean	Mean difference	*Z*	*P*
Dental follicle	6.30	8.61	1.57	-5.767	-2.067	0.039*
Dentigerous cyst	12.07	12.48	2.28			

Table 8: Comparison of mast cells in deep layer between dental follicle and dentigerous cyst

Lesion	Mean	Std Dev	SE of mean	Mean difference	*Z*	*P*
Dental follicle	6.07	11.76	2.15	-4.533	-1.807	0.071
Dentigerous cyst	10.60	13.71	2.50			

Table 9: Comparison of number of mast cells in inflamed and noninflamed cases of dental follicle

Dental follicle	Mean	*t*	95% confidence interval of significance		*P*
			Upper	Lower	
Inflamed cases	18.16667	3.881	8.5922	27.7411	<0.01
Noninflamed cases	0.60000	1.369	-0.2966	1.4966	

Table 10: Comparison of number of mast cells in inflamed and noninflamed cases of dentigerous cyst

Dentigerous cyst	Mean	*t*	95% confidence interval of significance		*P*
			Upper	Lower	
Inflamed cases	34.70000	5.306	21.3237	48.0763	<0.01
Noninflamed cases	0.73333	1.000	-0.7665	2.2332	

molars varies in the range of 17–21 years Table 1. The mandibular third molar is the most frequently impacted tooth. The incidence varies from 9.5% to 68% in different populations [Table 2],[20] followed by maxillary third molars with a reported frequency which varies from 16.7% to 73.82%. Maxillary canines also have reported with a high prevalence rate of followed by second premolars.[21]

Dental follicular space radiographically appears as thin pericoronal radiolucency, considered normal by some authors when the thickness is within 2.5–3 mm. The dental follicle may show various histopathological changes during tooth development, which may lead to the development of odontogenic tumors or cysts.[22] According to Saravana, if odontogenic epithelial lining of the dental follicle, changes from reduced enamel epithelium to stratified epithelium, it is indicative of dentigerous like changes.[23]

Because of the possible importance of mast cells in the pathogenesis of odontogenic cysts, an attempt was made by us to evaluate the presence and distribution of mast cells in different zones of the connective tissue.

Various stains are being used for staining mast cells like Romanowsky combinations (Wright, Giemsa, May-Grünwald Giemsa, and Leishman),[24] Azur A, Bismarck brown, Thionin Alcian blue, and toluidine blue.[18]

Hematoxylin and eosin staining is not a specific or reliable method for detecting mast cells in tissue sections because of variable cellular morphology [Figures 1a and 2a].[25] Hence, we choose to evaluate these cells by means of histochemistry through toluidine blue staining, which stains, mast cell granules purple in color due to the presence of heparin and histamine.[26]

Toluidine blue is also known as tolonium chloride and is an acidophilic metachromatic dye that selectively stains acidic tissue components.[26] Metachromatic staining of mast cells significantly depends on the number of factors such as type and maturity of mast cells, a test tissue type, animal species, a used dye, incubation solution pH and the staining duration, fixation solution type, fixation time, and the final processing technique of stained preparations.[27]

In our present study, we included 30 cases each of dental follicle and dentigerous cyst. In cases of dental follicle, we found greater predilection for males compared with females [Table 3]. The results were in accordance with a study done by Syed *et al*.[28] who found that males had a higher incidence of third molar impactions as compared to females.

Mast cells are found widespread throughout the connective tissue wall of all the cysts mainly in the subepithelial zone and are source of a variety of proteolytic enzymes found in the cystic fluid.[8]

The present study included evaluation of mast cells in subepithelial, intermediate, and deep layers in dental follicle; highest mean number of mast cells was recorded in subepithelial layer followed by intermediate layer and deep layer, respectively [Figure 1b-d] [Table 4]. The difference in mean number of mast cells among the groups was not statistically significant ($P > 0.05$). In dentigerous cyst, higher mean number of mast cells was recorded in subepithelial layer, followed by intermediate layer and deep layer, respectively [Figure 2b-d]. The difference in mean number of mast cells among the groups was not statistically significant ($P > 0.05$) [Table 5].

A study was conducted by Shylaja S *et al*.[18] using cases of radicular cyst, odontogenic keratocyst, and dentigerous cysts to evaluate the distribution of mast cells in subepithelial, intermediate, and deep zones. In all the abovementioned cysts, the maximum numbers of mast cells were seen in subepithelial zone compared to intermediate and deep zones. They stated that mast cell degranulation

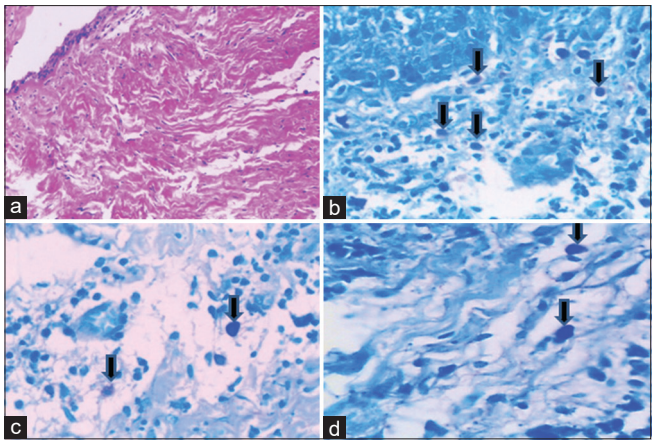

Figure 1: (a) Hematoxylin and Eosin stained tissue section of dental follicle. (b) Mast cells in toluidine blue stained tissue section of dental follicle in subepithelial layer. (c) Mast cells in toluidine blue stained tissue section of dental follicle in intermediate layer. (d) Mast cells in toluidine blue stained tissue section of dental follicle in deep layer

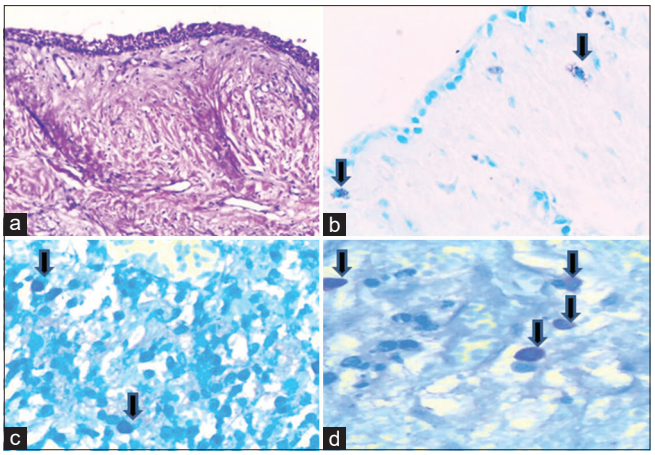

Figure 2: (a) Hematoxylin and Eosin stained tissue section of dentigerous cyst. (b) Mast cells in toluidine blue stained tissue section in subepithelial layer of dentigerous cyst. (c) Mast cells in toluidine blue stained tissue section of dentigerous cyst in intermediate layer. (d) Mast cells in toluidine blue stained tissue section of dentigerous cyst in deep layer

plays an important role in the inflammatory response and alteration in their number and distribution could contribute to the pathogenesis of odontogenic cysts.

Another study conducted by Chatterjee S *et al*.[8] to evaluate the mast cell distribution and cystic lining and capsule along 4 zones: intraepithelial, subepithelial, intermediate, and deep and found that mast cells had a greatest concentration in the subepithelial zone.

The results of our study showed that less number of mast cells was recorded in dental follicle compared with dentigerous cyst. Higher mean numbers of mast cells were recorded in the subepithelial layer followed by intermediate layer and deep layer, respectively, in both the lesions. There was statistically significant value ($P = 0.041$), between the number of mast cells in the subepithelial zones of dental follicle and dentigerous cyst [Table 6]. Significant association in the number of mast cells in the intermediate layer of dental follicle and dentigerous cyst was also noted ($P = 0.039$) [Table 7]. Although higher mean number of mast cells was recorded in the deep layer of dentigerous cyst compared with dental follicle, the difference between them was not statistically significant ($P > 0.05$) [Table 8].

Teronen *et al*.[29] stated that activated mast cells can synthesize vasoactive and chemotactic mediators (e.g., platelet activating factor) as well as several proinflammatory cytokines such as IL-3, IL-6, and TNF-α de novo. These chemical mediators increase vascular permeability, thereby facilitating influx of highly osmolar substances in cystic lumen.[8]

A study by Li *et al*.[30] found that the maximum width of the dental follicle was positively correlated with the incidence of inflammation in the dental follicle. In addition, it is well known that mast cells (MCs) initiate inflammation.[10]

In our study, in cases of dental follicle and dentigerous cyst, maximum inflammation was seen in the subepithelial layer followed by intermediate and deep layers. There was statistically significant increase in the number of mast cells in cases of inflamed dental follicle and inflamed dentigerous cyst with a P value of <0.01 [Table 9 and 10].

According to Shylaja S, the cysts of the developmental origin may show inflammatory changes secondary to infection. Mast cell histamine plays an important role in the inflammatory reaction, and they degranulate in response to antigen–antibody reaction on their surface. In addition, it is speculated that alterations in their number could contribute to the pathogenesis of odontogenic cysts.[18]

CONCLUSION

Histopathological analysis of mast cells in dental follicle and dentigerous cyst was conducted in our study. This type of analysis is important since high rate of pathosis in follicular tissues were found in many cases with the absence of any radio graphically detectable sign.

Analysis of mast cells was conducted using toluidine blue, which was simple and inexpensive method with less time consumption. Various studies have been conducted where they have proved that toluidine blue is a better stain compared with other stains like thionine in visualizing mast cells.

In the present study, the presence of mast cells was seen both in dental follicle and dentigerous cyst with higher

mean number of mast cells in dentigerous cyst. Highest concentrations of mast cells were seen in subepithelial zone of both the lesions which has been suggested to be due to a chemotactic stimulus attracting them to the epithelial lining or luminal fluid contents. Maximum numbers of mast cells were also seen in inflamed cases compared with noninflamed cases in both the lesions. Mast cells are considered to contribute towards cyst enlargement by increasing the osmotic pressure of the fluid in three ways: direct release of heparin, hydrolytic enzymes, and histamine.

In the present study, analysis of mast cells supports the existing view that mast cell may be considered one of the factor in the pathogenesis of odontogenic cysts.

Hence, we infer that the presence of inflammation may be associated with pericoronal follicle enlargement, a process that could result in cystic transformation of the follicle.

Hence, regular radiographic follow-up is necessary especially for teeth with a maximum dental follicle width of 2–3 mm, and combined team effort of the radiologist, pathologist, and the surgeon is important on arriving at a correct diagnosis.

Key messages

Mast cells play a significant role in the pathogenesis of dentigerous cyst, with their increased presence suggesting a potential to cystic transformation understanding their distribution in dental follicle and dentigerous cyst may provide insights into disease progression and early therapeutic interventions.

Financial support and sponsorship

From the Department of Oral Pathology and Microbiology, Vydehi institute of Dental Sciences and Research centre, Nallurahalli, Whitefield, Bengaluru, Karnataka, India.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Sayer CO, Rapley L, Mustelin T, Clarke DL. Are mast cells instrumental for fibrotic diseases? Front Pharmacol 2014;4:1-10.
2. Sivapathasundharam B. Text book of Oral Histology and Embrology. 2nd ed. Jaypee Publications; 2023.
3. Leeanansaksiri W, Dechsukhum C. The mast cells. Biomed J Sci Tech Res 2023;51:42548-52.
4. Kinet JP. The essential role of mast cells in orchestrating inflammation. Immnunol Rev 2007;217:5-7.
5. Walsh LJ. Mast cells and oral inflammatio`n. Crit Rev Oral Biol Med 2003;14:188-98.
6. Debta P, Debta F M, Chaudhary M, Wadhwan V. Evaluation of infiltration of immunological cells (Tissue eosinophil and mast cell) in odontogenic cysts by using special stains. J Clin Cell Immunol 2010;1:1-4.
7. Roberts ISD, Brenchley PEC. Mast cells: The forgotten cells of renal fibrosis. J Clin Pathol 2000;53:858-62.
8. Chatterjee S, Mahajan S, Boaz K, George T. Quantitative role of mast cells in odontogenic cystic enlargement. Braz J Oral Sci 2008;7:1662-5.
9. Doddamani A, Akshatha BK, Charlotte, Kumar V, Sharma R, Rohini VJ. Role of mast cells in aetiopathogenesis of radicular cyst. J Oral Med Oral Surg Oral Pathol Oral Radiol 2020;6:81–84.
10. Zhang Z, Kurashima Y. Two sides of the coin: Mast cells as the key regulators of allergy and acute/chronic inflammation. Cells 2021;10:1-19.
11. Zhou T, Pan J, Wu P, Huang R, Du W, Zhou Y, *et al*. Dental follicle cells: Roles in development and beyond. Stem Cells Int 2019;2019:9159605.
12. Kaur N, Manihani RK. Follicle Vs Dentigerous Cyst: Dilemma Revisited. Int J Res Health Allied Sci 2016;2:1-4.
13. Bastos VC, Gomez RS, Gomes CC. Revisiting the human dental follicle: From tooth development to its association with unerupted or impacted teeth and pathological changes. Dev Dyn 2021;251:408-23.
14. Dongol A, Sagtani A, Jaisani MR, Singh A, Shrestha A, Pradhan A, *et al*. Dentigerous Cystic Changes in the Follicles Associated with Radiographically Normal Impacted Mandibular Third Molars. Int J Dent 2018; 2018:2645878.
15. Tegginamani AS, Prasad R. Histopathological evaluation of follicular tissues associated with impacted lower third molars. J Oral Maxillofac Pathol 2013;17:41-4.
16. Gowrinathan N, Bindu Reddy CH, Husna Sofia ZH, Jemima R, Jeromy J, Dhanvantri NV. Case Report of a dentigerous cyst with mucous prosoplasia: As an incidental finding. SRM J Res Dent Sci 2020;11:229-32.
17. Shears M, Speight P. Cysts of the Oral and Maxillofacial Region. 4th ed. Blackwell Munksguard Publications; 2007.
18. Shylaja S. Mast cells in Odontogenic Cysts. J Clin Diagn Res 2010;4:2226-36.
19. Moghaddam MR, Bidokhty HA, Bijani A. Comparison of mast cells count in odontogenic cysts using histochemical staining. Iran J Pathol 2015;10:105-11
20. Secic S, Prohic S, Komsic S, Vukovic A. Incidence of impacted mandibular third molars in population of Bosnia and Herzegovina. A retrospective radiographic study. J Health Sci 2013;3:151-8.
21. Salam S, Bary A, Sayed A. Prevalence of impacted teeth and pattern of third molar impaction among kerala population. A Cross sectional study. J Pharm Bioallied Sci. 2023:354-357.
22. Ahmed J, Nath M, Sujir N, Ongole R, Shenoy N. Correlation of pericoronal radiolucency around impacted mandibular third molars using CBCT with histopathological diagnosis: A prospective study. Open Dent J 2022;16:1-10.
23. Satheesan E, Tamgadge S, Tamgadge A, Bhalerao S, Periera T. Histopathological and radiographic analysis of dental follicle of impacted teeth using modified Galego's stain. J Clin Diagn Res 2016;10:106-11.
24. Ribatti D. The staining of mast cells: A historical overview. Int Arch Allergy Immunol 2018;176:55-60.
25. Shukla SA, Veerappan R, Whittimore JS, Miller LE, Youngberg GA. Mast cell ultrastructure and staining in tissue. In: Krishnaswamy G, Chi DS, editors. Mast Cells. Methods in Molecular Biology. Vol 315. Humana Press; 2006. p. 63-76.
26. Sridharan G, Shankar AA. Toluidine blue: A review of its chemistry and clinical utility. J Oral Maxillofac Pathol 2012;16:251-5.
27. Grigorev lP, Korzhevskii DE. Modern imaging Technologies of mast cells for biology and medicine (review). Sovremennye technologii v medicine 2021;13:93-107.
28. Syed KB, Kota Zaheer, Ibrahim M, Bagi MA, Assiri M A. Prevalence of impacted molar teeth among Saudi population in Asir regions, Saudi Arabia-A retrospective study of three years. J Int Oral Health 2013;5:43-7.
29. Teronen O, Hietanen J, Lindqvist C, Salo T, Sorsa T, Eklund KK, *et al*. Mast cell-derived tryptase in odontogenic cysts. J Oral Pathol Med 1996;25:376-81
30. Li K, Xu W, Zhou T, Chen J, He Y. The radiological and histological investigation of the dental follicle of asymptomatic impacted mandibular third molars. BMC Oral Health 2022;22:1-9.