Comparative Histology of Parotid Glands in Mammals

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ABSTRACT

BACKGROUND
Parotid glands are one of the major salivary glands of mammals, responsible for production of the saliva. We wanted to do an interspecies comparison of the histology of mammalian parotid glands.

METHODS
Three (3) species were included in the study: human, pig and goat. Specimens were collected from study subjects in the adult age range. Acinar as well as ductal elements were observed under both low- and high-power objectives after staining the sections with routine haematoxylin and eosin stains.

RESULTS
Serous acini lined by serous cells were seen to occur in the parotid glands of all the three mammalian species. In human and pig, these cells were predominantly serous; whereas in goat, mucous cells were also noted amongst serous cells. In our study, striated ducts were found to be widely dispersed throughout the parotid glands of all the three mammals, constituting the largest portion of the duct system of mammalian parotid salivary glands.

CONCLUSIONS
Parotid glands are major salivary glands occurring bilaterally which exhibit considerable structural diversity among different species. A better knowledge of the cytoarchitecture and distribution of various elements in the different portions of the salivary excretory system is not only important from a biological point of view, but also because of their important role in the histogenesis of certain types of salivary gland tumours.

KEYWORDS
Parotid Glands, Mammals, Acini, Duct, Saliva

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BACKGROUND

As early as 160 A.D., Galen had described the position of the major and minor salivary glands and their respective ductal openings. Later, in 1543, Vesalius[1] published a more detailed anatomic description of the salivary glands in a monograph entitled 'de Humani corporis fabrica'. Parotid glands are one of the major salivary glands of mammals responsible for the production of saliva, a highly important link in the digestive chain. Saliva so produced by these glands serve many important functions like maintenance of oral health & dental hygiene, preparation of food for mastication, mediation of taste sensation, deglutition, initiation of preliminary phase of carbohydrate digestion, etc. Thus, a normal salivary flow is essential for normal bodily metabolism and is also essential to prevent undesirable pathophysiologic changes in other tissues/ organs[2]. Dry mouth (Xerostomia)[3] is a common complaint in the geriatric population and is commonly believed to arise from age-associated intrinsic salivary gland dysfunction. Mumps[4] is classically defined as an acute non-suppurative viral parotitis caused by paramyxovirus. The most common benign neoplasm of the salivary gland is Pleomorphic adenoma[5] originating in the parotid gland. Parotid carcinoma[6], although relatively rare, constitute a highly heterogeneous group exhibiting many histologic subtypes. Thus, the parotid gland architecture and the composition of saliva produced can change significantly in the presence of local or systemic diseases. Hence, knowledge of normal histological architecture of parotid gland is necessary to understand its various pathological conditions. In view of the wide spectrum of functions of the parotid glands, a comparative study of the mammalian parotid glands has been undertaken.

The proposed study was undertaken to observe mammalian interspecies comparative histological studies of Parotid Gland.

METHODS

The present study on mammalian parotid glands was conducted in the Department of Anatomy, Gauhati Medical College, Guwahati. The various species included in this study were human, pig and goat. After obtaining institutional ethical clearance, the specimens of mammalian parotid glands were divided into three (3) groups, consisting of six (6) to seven (7) numbers of mammals in each group as follows:

Sl. No.	Name of the Mammal	Group	No. of Specimens
1.	Human	I	7
2.	Pig	II	6
3.	Goat	III	6

Table 1. Grouping of, Species Under Study

All the three species under study were selected in the adult age range. The period from nine months to three years in pig corresponded to adulthood in human. Similarly, in case of goat, the corresponding age ranged between six to twenty-four months. Specimens of adult human parotid gland were collected from the cadavers within six hours of their death, following all legal formalities and after excluding all possible abnormalities and obvious pathological changes of the glands under study. Specimens for group II and group III species were obtained from department of Anatomy, College of Veterinary Sciences, Khanapara, Guwahati. Slides were prepared using standard laboratory procedure. The stained tissue sections (stained by routine haematoxylin and eosin, according to the standard methods laid down by Carleton, 1967)[7] were examined under low & high-power microscope to observe the distribution of acinar as well as ductal elements in the different mammalian groups.

RESULTS

The histological features of mammalian parotid glands were observed as follows**-**

Acinar Cells

Serous acini lined by serous cells were seen to occur in the parotid glands of all the three mammalian species. In human and pig, these cells were found to be predominantly serous (Figure 1, Figure 2), whereas in goat, mucous cells were also noted among serous cells (Figure 3). Under light microscope, the serous cells appeared pyramidal in shape having broader base and narrower apex (Figure 4). Nuclei of serous cells were found to be spherical in shape and basally located. The lumina of serous acini were difficult to visualize under light microscope. The most prominent feature of the serous cells was the accumulation of secretory granules in the apical cytoplasm. In routine histologic preparations, the serous granules are usually not well resolved, because of section thickness and the conditions of fixation. Therefore, the apical portion of serous cell may appear as an acidophilic mass. In our study using H & E staining, the apices of mucous cells appeared empty except for thin strands of cytoplasm forming a trabecular network. The nuclei along with thin rim of cytoplasm were seen to be compressed against the base of the cells. Nuclei of mucous cells appeared oval or flattened in shape and located just above the basal plasma membranes (Figure 5).

Ductal Elements

Intercalated (IC) ducts (Figure 6) were seen as thin branching tubes of variable length lined by a single layer of low cuboidal cells. Regarding the visibility under low power light microscope, the IC ducts were very sparsely noted in the slides of all the mammalian species under study.

Striated ducts (SD) were observed to be lined by a layer of tall columnar epithelial cells having large, spherical, centrally placed nuclei (Figure 7, Figure 8). The cytoplasm was found to be abundant and eosinophilic in nature and showed faint radially oriented lines (striations) at the basal ends of the cells, perpendicular to the basal surface (Figure

9). In our study using 400 x magnification, two types of cells were noted to line SDs – light cells (predominant) and basally located dark cells (occasional) were identified by their nuclear position, below the level of light cells. In our study, the SDs were found to be widely dispersed throughout the parotid glands of all the three mammals, constituting the largest portion of the duct system of mammalian parotid salivary glands presenting its intralobular component.

Excretory Ducts (ED) were observed to be present in the interlobular connective tissue septae in our study. In large ED, the epithelium was noted to be pseudostratified with increasing number of smaller basal cells between the tall columnar cells (Figure 10). Occasional mucous goblet cells might be found (Figure 10, Figure 11). In our study, the EDs of pig appeared to be larger in diameter and possessed more connective tissue support than the SDs. The EDs of pig were noted to be lined by numerous goblet cells (Figure 10) in addition to light, dark and basal cells. Basal cells did not reach the lumen and their large nuclei occupied most of the cytoplasm.

Species Under Study	Acinar Features	Ductal Features
Human	Predominantly serous acini lined by pyramidal cells having spherical & basally located nuclei. Apical cytoplasm appeared as acidophilic mass due to presence of zymogen granules. Acinar lumina difficult to visualize under LM.	**IC ducts**: thin branching tubes lined by a single layer of low cuboidal epithelium. **SDs**: prominent, widely dispersed, lined by a layer of tall columnar epithelial cells which showed faint striations at their basal aspects. **EDs**: observed in interlobular c. tissue septae, lined by pseudostratified epithelium.
Pig	Acini mainly serous lined by triangular shaped cells with basally located nuclei. Acinar cells termed as "special serous cells".	**IC ducts**: present but sparsely noted as they were compressed between secretory units. **SDs**: constituted largest portion of ductal system, lined by tall columnar cells having large, spherical, centrally placed nuclei. Cellular cytoplasm abundant & eosinophilic showing faint radiations. **EDs**: present in interlobular c. tissue septae lined by pseudostratified epi with increasing no. of smaller basal cells between tall columnar cells. Occasional goblet cells found. Large ED showed presence of light & dark cells.
Goat	Both serous & mucous cell lining acini present, serous cells outnumber the latter. Mucous cells appear empty & their nuclei along with thin rim of cytoplasm seen to be compressed against base of cells, nuclei appeared flattened or oval in shape.	**IC ducts:** present, often difficult to identify in routine histological prep due to their small size & lack of distinctive features. **SDs**: present, lined by a layer of tall columnar cells. **EDs**: large ducts lined by pseudostratified epithelium.

Table 2. Interspecies Comparative Histological Features of Mammalian Parotid Glands

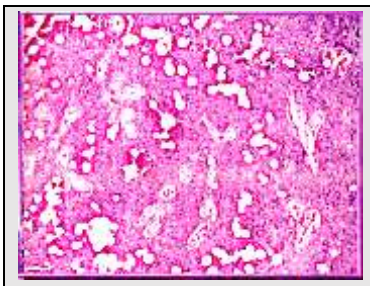

Figure 1. Photomicrograph of Human PG (X 100)

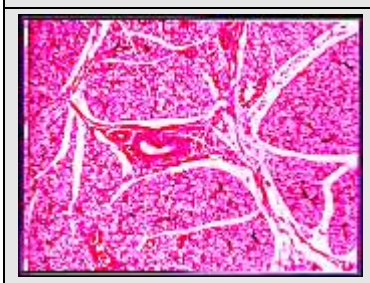

Figure 2. Photomicrograph of Pig PG (X 100)

Figure 3. Photomicrograph of Goat PG (X 100)

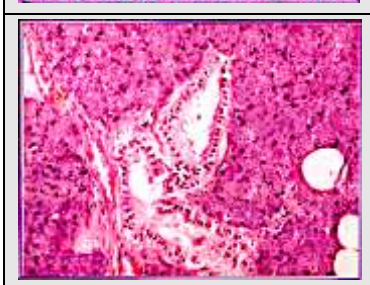

Figure 4. Photomicrograph of Human PG (X 400)

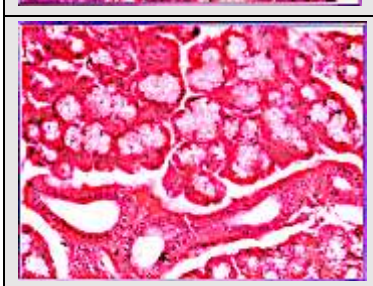

Figure 5. Photomicrograph of Goat PG (X 400)

Figure 6. Photomicrograph Showing Intercalated Duct (Green Arrow) and Striated Duct (Black Arrow) (X 100)

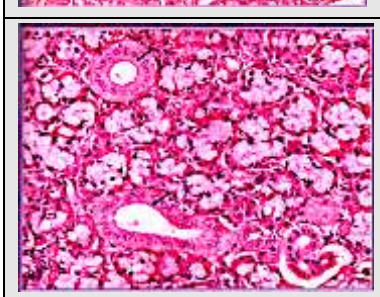

Figure 7. Photomicrograph Showing Striated Ducts (Black Arrows) (X 400)

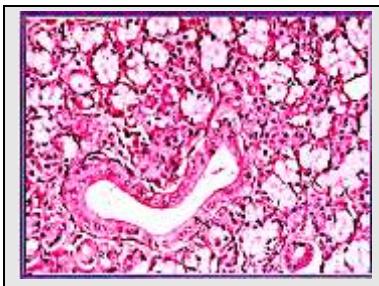

Figure 8. Photomicrograph Showing Large Sized Striated Duct (Green Arrow) (X 400)

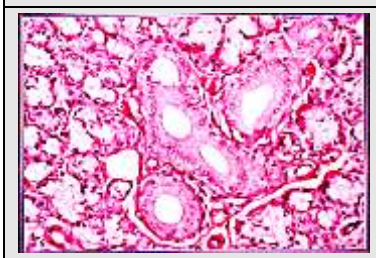

Figure 9. Photomicrograph Showing Striated Ducts in the Center of the Slide (X 400)

Figure 10. Photomicrograph Showing Epithelial Lining of Excretory Duct with Goblet Cell (Black Arrow) (X 400)

Figure 11. Photomicrograph Showing Lumen and Epithelial Lining of Excretory Duct (X 400)

DISCUSSION

The results obtained in this study were compared with the available established findings of other workers to draw a definite conclusion in the histological aspect of comparative study of mammalian parotid glands. The histological features of the mammalian parotid glands of all the three mammalian species (human, pig and goat) were studied under light microscope (LM) laying more emphasis on the type of acini and ductal structure.

Type of Acini

In all the three mammalian species, the parotid glands exhibited serous acini lined by serous cells. In human and pig, these cells were found to be predominantly serous; whereas in goat, mucous cells were also noted among serous cells. Renee R. Hukkanen, Piper M, et al; (2018)[8] stated that the parotid gland acini were composed entirely of serous cells, with variable amounts of intervening adipose tissue in the interstitium between parotid lobes. Under light microscope, the serous cells appeared pyramidal in shape, having basally located spherical nuclei. Lumina of serous acini were difficult to visualize under light microscope. Similar observations were also noted by S.N. Bhaskar (1980)[9]; James K. Avery, Daniel J. Chiego (1995)[10]; T.S. Ranganathan (2002) [11]; Leslie P. Gartner and James L. Hiatt (2007)[12]. In our study using H & E staining, the apices of mucous cells appeared empty except for thin strands of cytoplasm forming a trabecular network. Nuclei along with thin rim of cytoplasm were seen to be compressed against the base of the cells. Nuclei of mucous cells appeared oval or flattened in shape and located just above the basal plasma membranes. Similar observations on mucous cells were reported by Testa Riva (1977)[13]; Ham and Cormack (1979)[14]; Sahana (1985)[15]; Arthur R. Hand (2008)[16]. The type of acini may influence the feeding habit in herbivorous as well as carnivorous animal species (Elewa et al; 2014)[17].

- **Ductal Structure**

The duct system of mammalian parotid glands were observed to be formed by the confluence of smaller ducts into ducts of progressively larger calibre. The smaller ducts – intercalated (IC) ducts – connect the terminal secretory units to the next larger ducts, the striated ducts (SD). The latter gets emptied into excretory ducts (ED) which in turn coalesce to form the main excretory duct (Nanci, 2013)[18]. The parotid glands were found to be divided into lobules by connective tissue septae and the intercalated and striated ducts usually occupy an intralobular position, whereas the excretory ducts were usually interlobular in position.

The ductal histology is discussed under the following three headings:

- Intercalated ducts
- Striated ducts
- Excretory ducts

- **Intercalated Ducts (IC)**

Intercalated (IC) ducts were seen as thin branching tubes of variable length lined by a single layer of low cuboidal cells. This finding was found to be similar to that as reported by Riva et al. (1976)[19] and Tandler, Bernard *et al* (1978)[20] in the intercalated ducts of human parotid gland. Van Lennep et al (1977)[21] observed similar findings in the sheep parotid gland. Regarding the visibility under low power light microscope, the IC ducts were very sparsely noted in the slides of all the mammalian species under study. This has also been reported by Tandler, Bernard *et al*[20]. Arthur R. Hand (2008)[16] commented that due to small size of ductal cells and lack of distinctive features, IC ducts were often difficult to identify in routine histologic preparation. Many authors consider that these ducts harbour salivary gland stem cells (Ellis & Auclair, 2008)[22].

Striated Ducts (SD)

Striated ducts (SD) were observed to be lined by a layer of tall columnar epithelial cells having large, spherical, centrally placed nuclei. Similar pattern of cellular lining was reported by S. N. Bhaskar (1980)[9], Berkovitz et al. (1992) [23] and Nanci (2013)[18]. However, Leslie P. Gartner, James L. Hiatt (2007)[12]

stated that the SDs were composed of a single layer of cuboidal to low columnar cells. The cytoplasm was found to be abundant and eosinophilic in nature and showed faint radially oriented lines (striations) at the basal ends of the cells, perpendicular to the basal surface. Similar observations were also reported by Sahana (1985)[15]; James K. Avery, Danie J. Chiego (1995)[10]; and Arthur R. Hand (2008)[16]. In our study using 400 x magnification, two types of cells were noted to line SDs – light cells (predominant) and basally located dark cells (occasional). Such cellular pattern consisting of two cell types lining the SDs were previously reported by Riva et al. (1976)[19] in human parotid gland and Boshell and Wilborn (1978)[24] and Ginsbach and Kuhnel (1978)[25] in pig parotid gland. In our study, the SDs were found to be widely dispersed throughout the parotid glands of all the three mammals, constituting the largest portion of the duct system of mammalian parotid salivary glands presenting its intralobular component. This observation is similar to that as reported by S. N. Bhaskar (1980)[9] and Arthur R. Hand (2008)[16].

Excretory Ducts (ED)

In our study, excretory ducts were observed to be present in the interlobular connective tissue septae. In large ED, the epithelium was noted to be pseudostratified with increasing number of smaller basal cells between the tall columnar cells. Occasional mucous goblet cells were seen to occur (Fig. 10). Boshell and Wilborn (1978)[24] have described similar epithelial lining in the excretory ducts of pig parotid glands. In our study, the EDs of pig appeared to be larger in diameter and possessed more connective tissue support than the SDs. The EDs of pig were noted to be lined by numerous goblet cells in addition to light, dark and basal cells. Stinson, AL W. & Calhoun, M. Luis (1981)[26] noted the presence of goblet cells in the main EDs of pig parotid gland. The same was also being reported by Boshell L. Jerry and Wilborn H. Walter (1978)[24] and by Tandler, Bernard[20].

CONCLUSIONS

The Parotid glands in mammals are characterized by the presence of numerous units that consist of acini & a peculiar duct system. Different types of cells associated with these glands may bring about different changes in them. Interstitial lymphocytes may give rise to enlarged parotid lymph nodes. Heterotopic salivary tissue is found in many locations throughout the head & neck region. Age- induced variations & reactive changes include oncocyte proliferation, fatty infiltration, squamous & mucous metaplasia, hyperplasia, atrophy & regeneration. An analysis of the normal salivary gland structure permits a morphogenetic approach to an understanding of the variability in different pathological conditions. Dry mouth or xerostomia, mumps or viral parotitis, sialolithiasis or ductal calculi, etc. are some of the conditions which commonly affect the parotid glands. A better knowledge of the cytoarchitecture and distribution of various elements in the different portions of the salivary excretory system is not only important from a biological point of view, but also because of their important role in the histogenesis of salivary gland tumours. In fact, Parotid gland carcinoma is a highly heterogeneous group having many histologic subtypes. Thus, the parotid gland architecture & the composition of saliva can change significantly in the presence of local & systemic diseases. Hence, the understanding of normal histological architecture of these glands is necessary to know the various pathological conditions related to them. Currently, the majority of treatments for salivary gland diseases are symptomatic. A thorough understanding of the molecular mechanisms of salivary gland function will ultimately allow the treatment of salivary disease by gene replacement, permanently returning the gland to its homeostatic state. We have laid emphasis on the present histological aspects of parotid glands based upon the facts that are solidly established. There are many aspects in this field awaiting to be explored. This study may provide some insight to the workers in the field of otolaryngology and dental surgery.

Financial or Other Competing Interests: None.

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