Golgi-Cilium Complex in Rabbit Ciliary Process Cells

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ABSTRACT. We report here on a structural association of single cilia, via their striated rootlets, with the Golgi complex in epithelial cells and stromal fibroblasts of rabbit ciliary processes of the eye. The structure is designated a Golgi-cilium complex and its likely role in aqueous humor production is discussed.

The Golgi complex (1-3, 7) and the single cilium (9, 13, 14) have been studied in various cell types, but less extensively in the ciliary processes (8). The relationship between the cilium and Golgi complex has been neglected (9 for Refs) until recently, when Poole et al. (9) stressed that such association appears to be exclusive to the trans-Golgi face, thus assuming a new functional significance.

The present study extends Poole's hypothesis. Rabbits (n = 7) were anaesthetized and specimens were taken from the ciliary processes of the eyes and processed for TEM observation using the routine, glutaraldehyde-OsO₄, method. Ultrathin sections (uranyl acetate, lead citrate) at different planes of sectioning were examined with a JEM 7A or EM 109 Turbo (Opton) electron microscope.

No more than one cilium per cell was observed. Cilia were commonly found in nonpigmented and pigmented epithelial cells (NPEC and PEC, respectively) at their apico-lateral areas (Fig. 1a) and in ciliary channels. Two cases in which both cilia and the Golgi complex translocated into the basal part of PEC were recorded. A total of 63 ciliary profiles were documented and analyzed (31 in NPEC, 19 in PEC, 4 channelized cilia, 9 in stromal fibroblasts). Most cilia in NPEC (Fig. 1a) and PEC, but few in fibroblasts (Fig. 1b), showed a spatial relationship between their basal centriole-emerging rootlets and the Golgi complex. It is possible that through this study we are viewing the Golgi-rootlet association for the first time (Figs. 1a, c, and d), however, two recent reports have also illustrated this association (see Refs. 10 and 12) although the relationship was not discussed. Rootlets (10, 12 for Refs) have been shown in the ciliary epithelium (8), but these were not associated with the Golgi complex. We consider rootlets a predictive morphological sign of ciliation, i.e. by examining a “cilium-free”, rootlet(s)-containing cell section, one may predict the cell ciliation.

We designated the interrelationship between the Golgi complex and the cilium: Golgi-cilium complex; trans-Golgi-cilium complex being a most common variation. Considering the well known trans-Golgi-centrosome relation (2, 3, 7), the present finding of the Golgi-cilium complex appears to be a logical observation, although it has been, in a functional aspect, ignored by other authors except Poole et al. (9).

The function of the single cilium is hypothetical (8-10, 13, 14). The widespread occurrence of similar cilia in sensory cells, nervous and endocrine tissues, raises the
possibility that they may have some sensory role (9, 14). If so, the Golgi-cilium complex may provide a means by which the content of the aqueous humor and its production can be monitored. We propose that this complex and the ciliation in general in the ciliary processes would allow a local response to the altered composition of the intraocular fluid and the changes in the vascular pressure (8). We also found ciliation in the vascular endothelial cells and pericytes and in the Schwann cells of the ciliary process stroma (data not shown). The arrangement of ciliated cells in the ciliary processes may thus provide for one element of a system (ultrafiltration, diffusion, active secretion) maintaining the aqueous humor dynamics (5, 13). Considering the recent data on the role of cyclic AMP (a) at the trans-Golgi-centrosome area (2, 7) including that at the cilia-basal centriole (2), and (b) in the aqueous humor (6) and collagen/elastin (1) production, the Golgi-cilium complex may probably act via cyclic AMP. Rootlets, which link the Golgi complex, may be a signal-transmitting structure (4) and/or a contractile one (11). This may coordinate environmental signals with the respective cellular activity. Our study, still in progress, has shown that ciliation is rather well-expressed in the ciliary processes in human glaucomatous eyes. Further studies may precise the present results.

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**Fig. 1.** In NPEC, one longitudinal-sectioned cilium having a rootlet (R) that associates with the Golgi complex is shown (a). The average length of R is 0.47±0.21 (SD) μm (n = 22), the maximum length is 1.12 μm; the average thickness is 41.37±11.53 (SD) nm (n = 19), the maximum thickness is 60.0 nm; the periodicity of the cross-band is 54.83±9.48 (SD) nm (n = 35), the maximum cross-band period is 70.0 nm; no intraperiod subbands are visible (Ref. 10). In Fig. 1b, one longitudinal-sectioned cilium that associates with the trans-Golgi face is shown in a ciliary process stromal fibroblast. Several rootlets (R) that appear to be anchored to the trans-Golgi area in NPEC (c, d).

×20,000 (a, d), 17,000 (b), 30,000 (c)


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