Rhinology, 30, 49-56, 1992

Ultrastructural findings of capillaries in nasal polyps

Kensuke Watanabe and Atsushi Komatsuzaki

Dept. of O.R.L., Tokyo Medical and Dental University, Tokyo, Japan

SUMMARY

The permeability of capillaries in nasal polyps is very high. The continuous capillary is the typical type but the discontinuous type and fenestrated type are also observed. These fenestrated capillaries are found near the stalk region. Although discontinuous capillaries undoubtedly have high permeability, many morphological findings which show this high permeability are observed even if they are continuous capillaries. There are many endothelial projections into the capillary lumen, well-developed marginal folds and pinocytotic vesicles. The endothelial projections complicatedly agglutinate to another part of the endothelium or projections and sometimes form the reticulation. Morphological findings inhibiting the interstitial oedema are also observed. Several layers of basement membrane appear around the capillaries, endothelial projections into the interstitium and the formation of the appositional junction between the pericytes and endothelium. Well-developed basement membrane inhibits the leakage of large molecules. The large spaces which are enclosed by external projections demonstrate the efficient absorption of interstitial fluid. The external projections and the formation of the appositional junction between pericyte and endothelium may support the findings of the rebirth capillaries. The capillaries in nasal polyps are very small in number. If the capillaries or venules were quickly created the interstitial fluid would be efficiently absorbed in the vessels.

INTRODUCTION

Nasal polyps are observed in a variety of clinical conditions, which include allergic rhinitis, chronic sinusitis and cystic fibrosis. However, they have a relatively constant histological appearance instead of a different aetiology. They consist essentially of an edematous stroma which contains numerous infiltrated cells (Tos and Mogensen, 1977; Sørensen et al., 1977), small numbers of glands (Takasaka et al., 1986) with or without cystic distension and only a few blood vessels (Cauna, 1972).

The interferences of drainage of the interstitial tissue fluids and venous flow finally produce the edematous stroma, regardless of the clinical conditions. The vascular density and permeability therefore assume an important role in the growth of nasal polyps.
The present study was designed to clarify the ultrastructural characteristics of the capillaries in nasal polyps and speculate on the role of capillaries in their formation.

MATERIALS AND METHOD

Seven nasal polyps measuring from 5 to 20 mm in length were obtained surgically under topical anaesthesia with 1% Xylocaine®. The age of patients ranged from 20 to 45 years. Four patients had allergic rhinitis and three patients had chronic sinusitis with negative skin test against major inhalant allergens.
The polyps were fixed in 2% glutaraldehyde with 0.1 M cacodylate buffer, pH 7.4, at 4 °C for two hours and then washed three times in 0.1 M cacodylate buffer (pH 7.4) containing 8% sucrose. They were postfixed in 1% OsO_4 in 0.1 M cacodylate buffer for one hour at 4 °C and then dehydrated with ethanol and embedded in Epon 812. Ultrathin sections were cut on a Porter Blum Type II ultramicrotome. They were stained with uranyl acetate and lead citrate and then examined by transmission electron microscopy. For lightmicroscopical observation, thick sections were cut and stained with toluidin blue. As controls the nasal mucosae of inferior turbinates were observed by light microscopy.

RESULTS

The polyps were less vascular than the nasal mucosa (Figures 1 and 2). Although many fenestrated capillaries were found near the stalk region (Figure 3), almost all capillaries were of the continuous type (Figure 4). The open endothelial junctions were also observed although they were small in number (Figure 5). The borders of the endothelial cells were clearly delineated (Figure 5, insert). Capillaries were observed near the surface epithelium but very few capillaries were found in the central area of the polyp where the stroma was very edematous.
The basement membrane system was well developed, with several layers of it surrounding the capillary (Figures 3 and 4). The capillary endothelium was characterized by many endothelial projections into the capillary lumen. The tips of the projections agglutinated to other parts of the endothelial cell membrane, which formed large vacuoles, sometimes causing a reticulated formation (Figure 6). Developed marginal folds were also frequently observed (Figure 7, arrow M). The projections in the direction of the interstitium were also observed (Figure 4, arrow). The basement membrane was observed in the newly enclosed lumen (insert of Figure 8, arrow).
The endothelium was supported by sparse pericytes. The pericytes possessed cytoplasmic processes or pseudopodia (Bruns and Palade, 1968) which penetrated

the endothelial basement membrane and formed appositional junctions with the endothelial cells (Figure 6 and Figure 7, small arrow). In some parts where the enclosed space was nearly completed, the space between the endothelial cell and pericyte was devoid of the basement membrane (Figure 7, snow mark). Many pinocytotic vesicles were observed in the endothelium (Figure 7, arrow P).

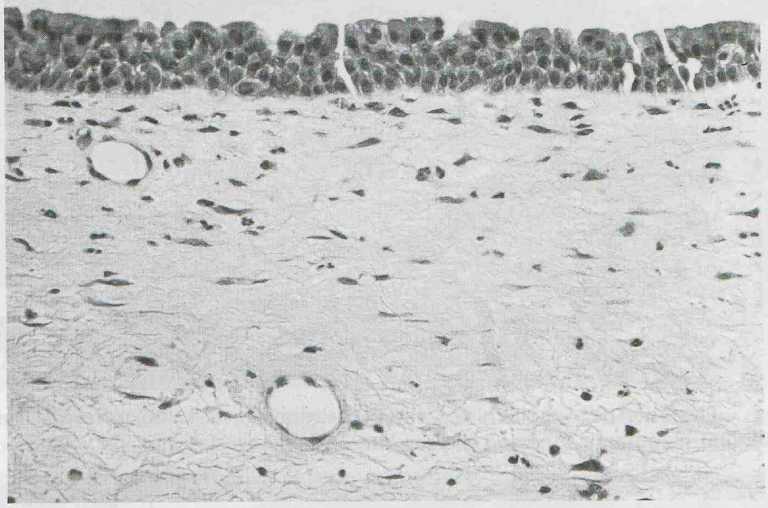

Figure 1. Nasal polyp. Very few capillaries are observed in the edematous stroma. x 230

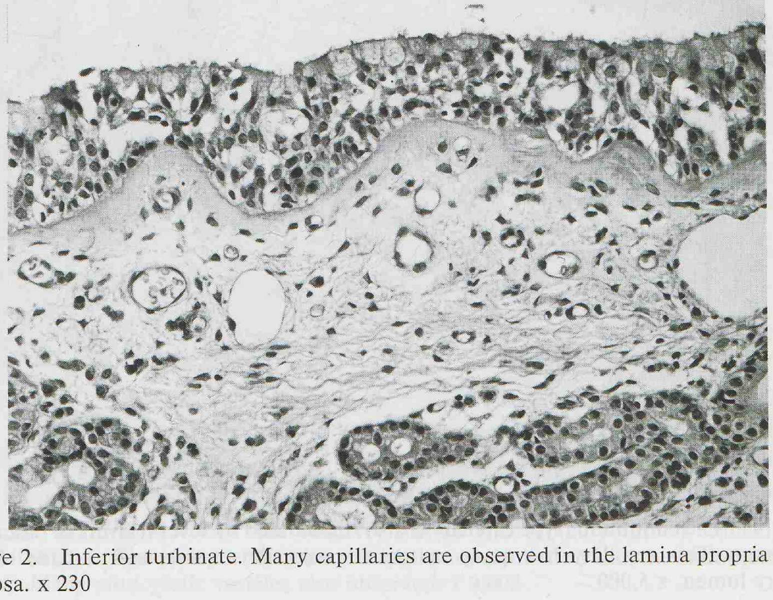

Figure 2. Inferior turbinate. Many capillaries are observed in the lamina propria of the mucosa. x 230

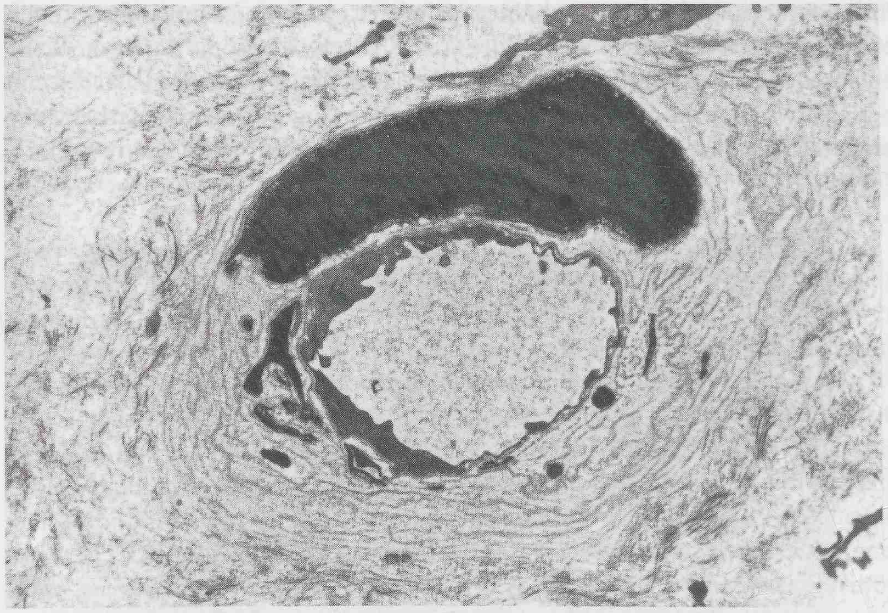

Figure 3. The fenestrated capillary near the stalk region of a nasal polyp. Several layers of the basement membrane surround the capillary. x 6,600

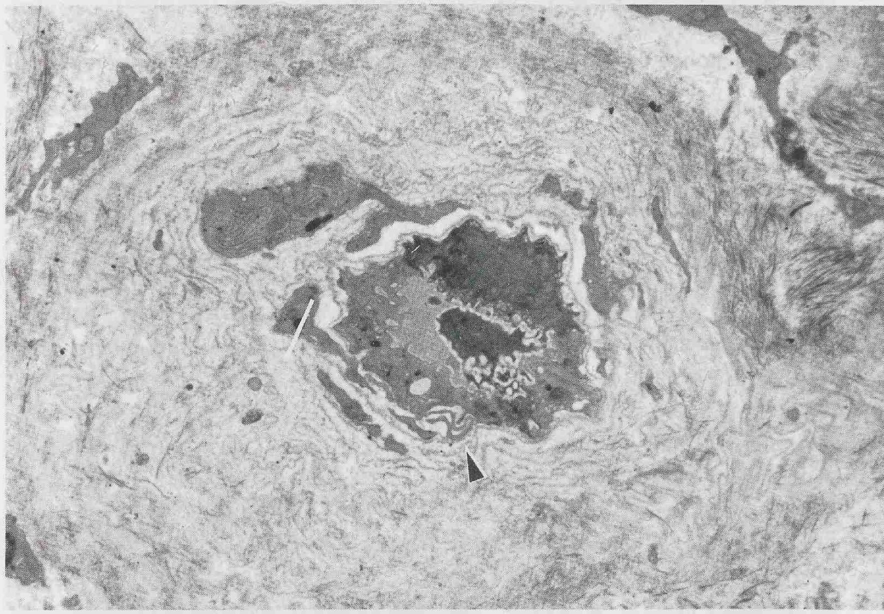

Figure 4. The continuous type capillary is also surrounded by several layers of basement membrane. This capillary has many epithelial projections inside and outside of the capillary lumen. x 5,000

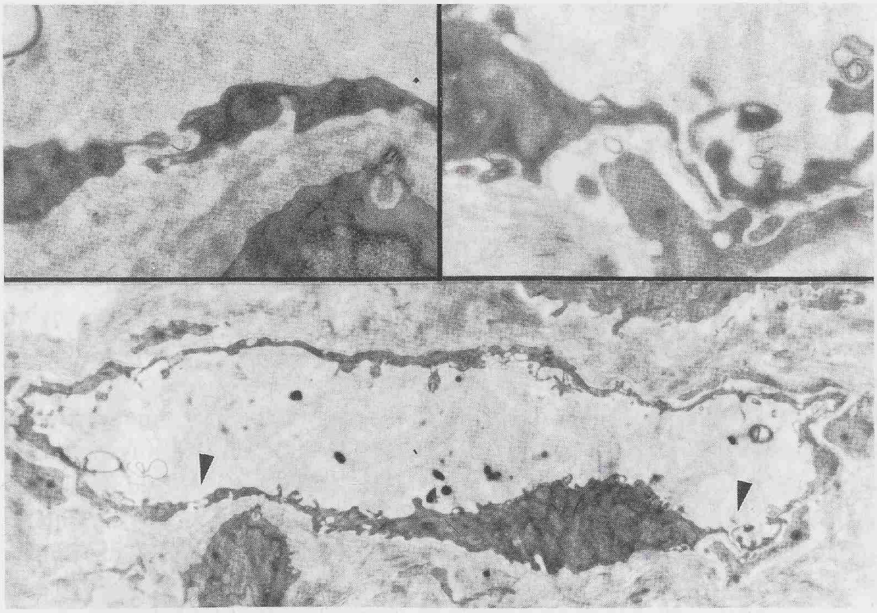

Figure 5. The discontinuous type capillary. The epithelium is open at two portions (arrows). The insert shows high magnification of the arrowed portions. x 4,500. Insert: x 18,000

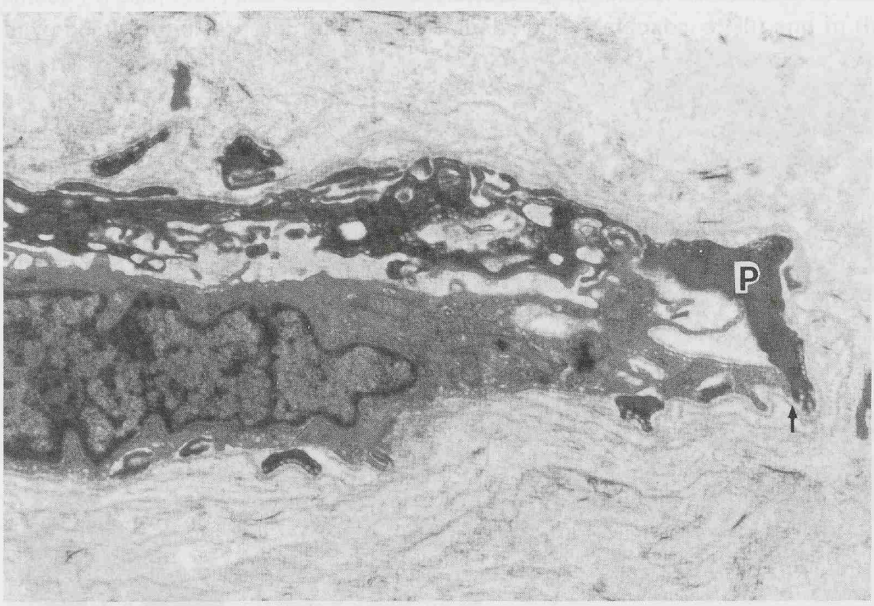

Figure 6. Many projections are observed inside the capillary lumen, causing the reliculated form. The pericyte (P) forms the appositional junction with the endothelial cell (arrow). Many pinocytotic vesicles also observed. x 9,000

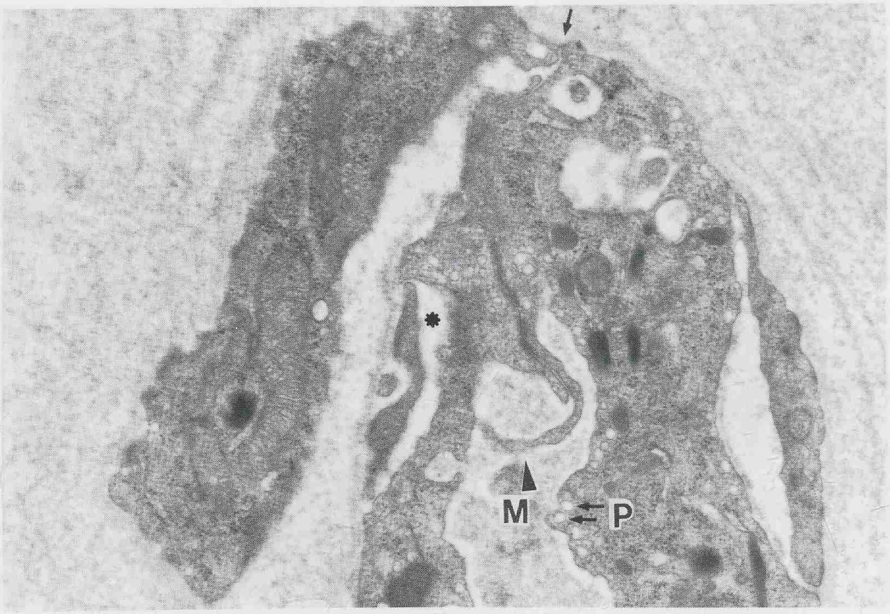

Figure 7. The pericyte adheres to the endothelium (arrow). No basement membrane is observed in the enclosed space which is near completion (snow mark). Many pinocytotic vesicles (P) are observed. M: marginal fold. x 17,000

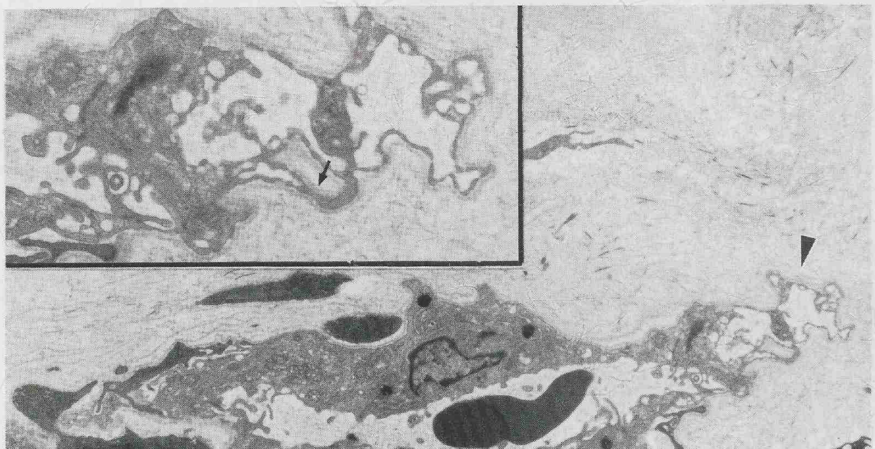

Figure 8. The basement membrane is observed in the newly enclosed lumen (insert: arrow). The insert shows high magnification of the large arrow portion. x 4,000. Insert: x 10,000

DISCUSSION

The present study disclosed that the nasal polyp capillaries had characteristic morphological features, which were both findings of increasing and decreasing the interstitial tissue edema.

Capillaries are classified into three principal classes (Bennett et al., 1959): 1) continuous capillaries, 2) fenestrated capillaries, 3) discontinuous capillaries. Mayerson et al. (1960) indicated that the permeability increased in the order of continuous capillaries < fenestrated capillaries < discontinuous capillaries. This study revealed that all three different types of capillaries were observed in nasal polyps.

Many morphological findings which indicated high capillary permeability were observed even if the capillaries were of the continuous type. There were many endothelial projections into the capillary lumen, well-developed marginal folds and pinocytotic vesicles. Although these findings were also observed in the capillaries of the nasal mucosa (Watanabe and Watanabe, 1980), there was no reticulated formation. In nasal polyps, the endothelial projections complicatedly agglutinated to other parts of the endothelium and projections, sometimes causing the reticulated formation. This indicates that capillary permeability of nasal polyps is higher than that of nasal mucosa.

Discontinuous capillaries are found in liver (Hampton, 1958; Bennett et al., 1959) spleen (Weiss, 1957) and bone marrow (Bennett et al., 1959). More recently they have been found in nasal mucosa (Watanabe and Watanabe, 1980) and in the mucosa of maxillary sinus (Hirota and Watanabe, 1989). In nasal mucosa, they are observed in the anterior area, not in the posterior area (Watanabe and Watanabe, 1980). In paranasal mucosa, they are observed in the vicinity of ostium of the maxillary sinus (Hirota and Watanabe, 1989). Since the nasal polyps which we removed originated from the vicinity of the ostium of the maxillary sinus, the discontinuous capillaries are thought to be observed in nasal polyps.

High capillary permeability is an important factor causing the interstitial edema. However, the morphological findings which inhibit it are also observed. The basement membrane system surrounding the capillary was well developed in nasal polyps. This finding runs contrary to the high capillary permeability because the basement membrane can function as an additional, coarser permeability barrier (Clementi and Palade, 1969). This may mean homoeostatic changes that inhibit the leakage of large molecules. Many external projections of endothelium are also found to decrease the interstitial edema. The large vacuoles which are enclosed by these projections are transported in the endothelial cytoplasm and are absorbed inside the capillaries. A large amount of fluids is efficiently transported by this mechanism.

The folds or projections to the interstitium may be the initial presentations of the rebirth capillaries. Schoefl (1964) reported that the endothelial projections were the initial change underlying the regeneration of blood vessels and that these cytoplasmic processes were most frequently seen near the advancing vascular tip. It is also thought that the formation of the appositional junction between the cytoplasmic processes of pericytes and endothelial cells is the morphological presentation of the neovascularization. One of the important reasons why the interstitial fluid is accumulated is the small number of vessels. If the capillaries or venules were quickly created in nasal polyps the interstitial fluid would be efficiently absorbed in the vessels.

One more root besides blood vessels draining the interstitial fluid is the lymphatic vessels. Since the lymphatic flow is passive, it is easily stagnated by the pressure. And because the osteum of the maxillary sinus is narrow, the lymphatics are pressured by mucous swelling caused by slight inflammation. The present authors think that the stagnation of the lymphatic flow represents an important role operating at the first stage of polyp formation. Krajina (1963) and Smith (1967) reported the relation between the stagnation of lymphatic flow and nasal polyps. We intend to report the characteristics of lymphatics in nasal polyps in our next paper.

REFERENCES

1. Bennett HS, Luft JH, Hampton JC. Morphological classification of vertebrate blood capillaries. Am J Physiol 1959; 196: 381–390.
2. Bruns RR, Palade GE. Studies on blood capillaries. J Cell Biol 1968; 37: 244–299.
3. Cauna N, Hinderer KH, Manzetti CW, Swanson EW. Fine structure of nasal polyps. Ann Otol 1972; 81: 41–58.
4. Clementi F, Palade GE. Intestinal capillaries. II Structural effects of EDTA and histamine. J Cell Biol 1969; 42: 706–714.
5. Krajina Z. A contribution to the aethiopathogenesis of the nasal polyps. Pract Oto-Rhino-Laryng 1963; 25: 241–246.
6. Hampton J. An electron microscope study of the hepatic uptake and excretion of submicroscopic particles injected into the blood stream and into the bile duct. Acta Anat 1958; 32: 262–291.
7. Hirota A, Watanabe K. Characteristics of the capillaries in paranasal sinus. Jpn J Rhinol 1989; 28: 202.
8. Mayerson HS, Wolfram CG, Shirley HH, Wasserman K. Regional differences in capillary permeability. Am J Physiol 1960; 198: 155–160.
9. Schoefl GI. Electron microscopic observations in the regeneration of blood vessels after injury. Ann NY Acad Sci 1964; 116: 789–802.
10. Smith RE. Treatment of nasal polyps and hypertrophic allergic rhinitis. Ann Allergy 1967; 25: 355–358.
11. Sørensen H, Mygind I, Flensborg EW. Histology of nasal polyps of different etiology. Rhinology 1977; 15: 121–128.
12. Takasaka T, Kaku Y, Hozawa K. Mast cell degranulation in nasal polyps. Acta Otolaryngol 1986; Suppl 430: 39–48.
13. Tos M, Mogensen C. Pathogenesis of polyps. Rhinology 1977; 15: 87–95.

Kensuke Watanabe, M.D.
Dept. of O.R.L.
Dokkyo University School of Medicine
Koshigaya Hospital
2-1-50 Minami-Koshigaya, Koshigaya,
Saitama 343, Japan