3 Malformations of the Telencephalic Commissures
Callosal Agenesis and Related Disorders

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3.1 Introduction

“Callosal agenesis” is a misnomer. Modern imaging with magnetic resonance (MRI) allows for a detailed anatomic study of the malformation, and demonstrates that in at least 90% of the cases, absence of the corpus callosum is only part of the disorder: typically, the hippocampal commissure is also missing or incomplete. Therefore, the term “commissural agenesis,” or “agenesis of the (forebrain) commissures” should rather be used [1].

In our experience, defects of the telencephalic commissures are the most common malformation of the central nervous system found by MRI in utero [2, 3]. This raises difficult problems of management, as the functional prognosis is uncertain. Many authors have long contended that absence of the corpus callosum per se (the hippocampal commissure was neglected) would not be responsible for any clinical disorder [4]. Only associated malformations would generate the clinical features [5, 6]. In those times, most patients were diagnosed by autopsy or by reluctantly applied radiographic methods, such as pneumoencephalography or angiography. This may have introduced a bias in the detection of affected patients. More innocuous modern imaging modalities are used more liberally in patients with neurological or psycho-intellectual deficits, and demonstrate quite a strong correlation between the pathology and the presence of clinical disorders; the latter, however, seem to be extremely diverse and unpredictable, while the name of “callosal agenesis” is univocal and lacks specificity. Today’s imaging provides exquisitely detailed depiction of morphologic abnormalities. One may presume that a more detailed classification of the abnormalities based on precise anatomical features might uncover more pertinent radiological-clinical correlates, and therefore would allow for more secure prognostic expectations.

Although the interhemispheric commissures have seemingly been rediscovered in the 1980s thanks to the acquisition of midline sagittal cuts from MRI, their agenesis has been known for a long time.
Bianchi [7] was the first to describe it (see Bull [8]) in 1749. Reil [9] produced the first detailed autopsy report of a woman with complete agenesis. Forel and Onufrowicz (quoted by Déjerine [10]) already emphasized that agenesis of the hippocampal commissure was associated with the agenesis of the corpus callosum. In 1892, Sachs [11] recognized that the bundle of fibers that run parallel and medial to the lateral ventricle is made of the rerouted fibers of the corpus callosum, and therefore considered it an “heterotopia of the corpus callosum,” rather than an agenesis. This was nine years before M. Probst [12] gave this bundle the name of Balkenlängsbündel, which was translated as the “longitudinal bundle of Probst,” or for simplicity “Probst’s bundle.” Later, the diagnosis became possible in vivo by pneumoencephalography, and Davidoff and Dyke [13] gave the first detailed radiological description of the malformation in 1934. More material was produced by Feld [14] on a pediatric series with clinico-radiologic correlates, and, in the same book, by Gross and Hoff [15] who reported on a large series of 40 autopsy cases, noting that even the longitudinal “heterotopic” bundle could be missing. Then, in 1968, Loeser and Alvord [16] gave a magisterial description of the malformation. In their paper, amongst other observations, they stressed the fact that the laminae of white matter which close the lateral ventricles medially are truly the leaves of the septum pellucidum (kept apart from the midline in the absence of commissuration and of the resulting interhemispheric approximation). This ill-located septal leaf contains the longitudinal bundle of Probst dorsally, and the longitudinal fornix ventrally. They noted that in rare cases, the corpus callosum alone could be missing, with a patent hippocampal commissure, and reported also on the total absence of callosal fibers, without a longitudinal bundle. The same year, Rakic and Yakovlev [17] reviewed the embryological concepts and provided their own analysis of the development of the telencephalic commissures, which after 35 years is still the reference paper.

As clinically recognized cases were becoming more common, updates were published by Bull [8] and especially by F.P. Probst [18], whose sum is full of still valuable data. More recent works have mostly addressed modern imaging [19–22] and have attempted to organize the concepts about this malformation [1, 23].

For a clear understanding of the abnormalities encountered in the patients affected with commissural disorders, the following points will be addressed. Our description is based on the assumption that different morphologic types of commissural agenesis may represent different diseases.

- Radiological anatomy, morphogenesis, imaging of the telencephalic commissures and midline cysts;
- Common form of commissural agenesis, either complete or partial;
- Commissural agenesis associated with meningeal dysplasias (either multicystic or more rarely lipo-matous);
- Isolated agenesis of a single commissure;
- Other varieties of commissural dysplasias;
- Related malformations.

3.2 The Anatomy and Morphogenesis of the Forebrain Commissures

3.2.1 Normal Radiological Anatomy

The telencephalic commissures are cortico-cortical bundles of white matter extending from one hemisphere to the other, typically but not absolutely in a symmetrical fashion (i.e., corpus callosum) (Fig. 3.1). Association bundles are cortico-cortical bundles of white matter extending from one area of the cortex to another area within one hemisphere (i.e., superior longitudinal bundle, arcuate fibers). Projection tracts are cortico-subcortical bundles of fibers extending between the cortex and subcortical structures (i.e., thalamocortical and corticospinal tracts).

The interhemispheric (or telencephalic) commissures are the anterior commissure, the corpus callosum (the most prominent of all in humans), and the hippocampal commissure (or psalterium). An anterior commissure and a hippocampal commissure are found in all vertebrates, whereas the corpus callosum is found in placental mammals only. Surrounded by these commissures, the septum pellucidum also carries commissural fibers. Because the commissures have developed close to the limbic structures, they have special anatomic relationships with the cingulum and the cingular gyrus, and obviously with the hippocampus.

3.2.1.1 Anterior Commissure

The anterior commissure extends from one hemisphere to the other in the depth of the anterior portion of the basal ganglia, crossing the midline at the upper end of the lamina terminalis of the third ventricle (which belongs to the telencephalon: telencephalon medium, or impar) [24]. It relates mostly to the olfac-