Congenital limb deficiencies associated with Klippel-Feil syndrome

A survey of 57 subjects

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ABSTRACT – We reviewed data from 57 patients (40 women) with Klippel-Feil syndrome to identify and characterize limb deficiencies. The cervical synostosis was classified according to the description of Feil (1919). Limb deficiencies were classified according to Henkel et al. (1978) and compared with the sclerotome theory of McCredie and Willert (1999).

In a wide variety of combinations of Klippel-Feil syndrome (types I–III) and other anomalies, only 5 patients had a longitudinal upper limb deficiency (one arm or both arms). 4 patients had Klippel-Feil syndrome type II and 1 had type I. 4 patients had "longitudinal distal radial deficiencies", Henkel types 1, 2, 4 and 5 and 1 patient showed "longitudinal combined humero-ulna deficiencies" types 2 and 3 of both arms. The lower limb was not affected.

The combination of Klippel-Feil syndrome and upper limb deficiency shows that the defect occurred between the 4th and 5th week of gestation.

Sclerotome 6 was mainly affected in our study. In 4 of the 5 patients, the cervical fusion level and sclerotome level of the limb deficiency clearly or partly matched, whereas there was no agreement in 1 patient.

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The Klippel-Feil syndrome, congenital synostosis of the cervical vertebrae or brevicollis anomaly, refers to defects of segmentation or fusion of the cervical spine. Short neck, low posterior hairline, and limitation of motion of the head or the neck are the commonest clinical features (Klippel and Feil 1912a,b, Feil 1919). This disorder results from failure of normal segmentation of the somites during the 3rd to 8th week of gestation. Although numerous studies describe anomalies associated with the Klippel-Feil syndrome (Wolpert 1976, Winter et al. 1984, Bavinck and Weaver 1986), to our knowledge there are no reports on the combination with longitudinal limb deficiencies.

We assessed limb deficiencies associated with the Klippel-Feil syndrome and characterized them according to a recent description of the sclerotome pattern (McCredie and Willert 1999).

Patients and methods

We reviewed clinical and radiographic data from 57 patients (40 women) with Klippel-Feil syndrome treated in the Department of Orthopedics from 1969 to 1994. The average age at the first presentation was 12 (0.5–49) years. We used the classification of Klippel and Feil (1912a) and Feil (1919). Type I has a massive fusion of many cervical and upper thoracic vertebra synostosis. Type II shows only cervical fusion and type III shows cervical and lower thoracic or lumbar fusions. Other anomalies were recorded. The limb deficiencies were classified using of Henkel at al.'s system (1978), which is accepted as an international standard. Henkel distignuished between teratological sequences and longitudinal deficiencies. The longitudinal deficiencies were divided into proximal longitudinal, distal longitudinal and combined longitudinal. Then they were subdivided by the skeletal elements involved and the degree of in-

Survey of the 5 cases: the level of the cervical synostosis and type of Klippel-Feil syndrome, the type and side of the limb deficiency, the sclerotome level and match (grades 1–3)

Case No.	Cervical synostoses	Klippel-Feil Type	Limb deficiencies Type	Side	Sclerotome Type	Grade
1	C 2–3 / 5–7	II	Long. dist. radial (c), metacarp. I (c), phalang. I (c)	R	6 / partly 7	2
2	C 5–7	II	Long. dist. metacarp. I (p), phalang. I (h)	R	6	2
			Long. dist. metacarp. I (p), phalang. I (h)	L	6	2
3	C 4–7	II	Long. comb. humeral (h, s), ulna (p, s), radial (p, s), carpal (p, s), metacarp. III–V (c), phalang. 3–5 (c)	R	5-7	2
			Long. comb. humeral (p, s), ulna (p, s), radial (p, s), carpal (p, s), metacarp. III–V (3m, s), phalang.3–5 (3m, s)	L	5-7/ partly 8	1
4	C 1–2 / 6–7	II	Long. dist. radial (p), metacarp. I (c), phalang. I (c)	L	6	1
5	C 4–Th 5	I	Long. dist. radial (h), metacarp. I (p), phalang. I (h)	L	6	3

(c) complete, (p) partly, (h) hypoplastic, (s) synostosis, (3 m) 3 missing.

volvement of each bone (complete, partial and hypoplastic).

To grade the relationship between the sclerotomes and the longitudinal limb malformations, we used 3 grades according to McCredie and Willert (1999):

Grade 1. The longitudinal defect clearly coincided with the sclerotome map.

Grade 2. The longitudinal defect had a less obvious or uncertain match with the sclerotomes.

Grade 3. The longitudinal defect coincided poorly or not at all.

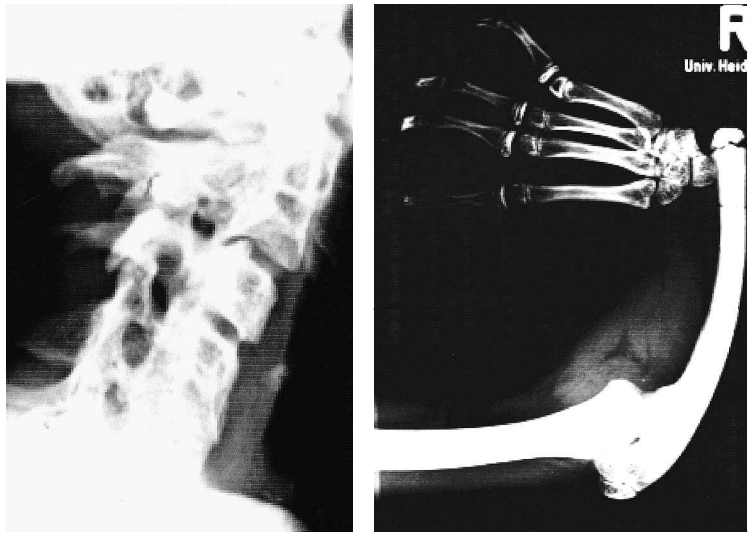
Results

23 patients had Klippel-Feil syndrome type I, 27 type II and 7 type III. Scoliosis was the most frequent orthopedic anomaly and was found in 40 patients. In 38 patients, a combination with other disorders was observed. A Sprengel deformity was seen in 15 patients. 5 patients had longitudinal upper limb deficiencies of one (3 patients) or both (2 patients) arms. 4 of the 5 patients with a limb deficiency had a type II syndrome. In some other cases, we noted different syndromes. We found no lower limb deficiencies.

The 5 patients had different upper limb deficiencies, all longitudinal (Table).

Case 1 corresponds to type II with synostoses from C2 to C3 and from C5 to C7 (Figure). Absence of the radius, the first metacarpal and the thumb accords with a "longitudinal distal radial defect" (Henkel, type 5). According to McCredie and Willert (1999), this syndrome may be due to an injury of the 6th cervical nerve in the embryo which inhibits the 6th and partly the 7th sclerotome (grade 2).

Case 2 had a type II syndrome with synostoses from C5 to C7. Bilateral absence of the first



A 15-year-old boy (case 1) with synostosis of C2–C3 and C5–C7 and the right arm with radial clubhand (for details, see text).

metacarpal and a hypoplastic thumb accord with a "longitudinal distal radial defect" (Henkel, type 1). According to McCredie and Willert (1999), the 6th sclerotome affects both arms (grade 2).

Case 3 had a type II syndrome with synostosis from C4 to C7 and malformations of both arms. The right arm showed humerus hypoplasia with synostosis to the partly developed ulna and a hypoplastic radius with synostosis. The combination of a partly developed carpus and absence of the metacarpus and phalanges of digitus 3–5 is called a "longitudinal combined humero-ulnar defect" (Henkel, type 2). The left arm showed a partly developed humerus with synostosis to the partly developed radius and ulna, a partly developed carpus and a complete absence of the metacarpus and phalanges of digitus 3–5, and synostosis of the rest phalanges. This corresponds to a "longitudinal combined humero-ulnar defect" (Henkel, type 3). According to McCredie and Willert (1999), this syndrome involves the 5th to the 7th (right, grade 2) or even part of the 8th (left, grade 1) sclerotome.

Case 4 had a type II syndrome with synostosis from C1-C2 and C6 to C7. A longitudinal 2/3 radial defect, with absence of the first metacarpal and thumb. The hypoplastic metacarpal II and index finger are classified as a "longitudinal distal radial defect" (Henkel, type 4). According to McCredie and Willert (1999), this defect is ascribed to be maldevelopment of the 6th sclerotome (grade 1).

Case 5 had a type I syndrome with synostoses from C4 to Th 5. The hypoplastic radius, a hypoplastic first metacarpal and thumb comprise the group of a "longitudinal distal radial defect" (Henkel, type 2). Involvement of the 6th sclerotome is assumed (grade 3).

Discussion

The clinical manifestations of the Klippel-Feil syndrome vary according to the severity of the deformity. The combination with numerous other syndromes and/or anomalies suggests a basic general disorder of skeletal development (Winter et al. 1984). However, a vascular-disruptive pathogenesis must also be considered (Bavinck and Weaver 1986), which might be account for the upper limb malformations.

5 of our 57 patients had longitudinal upper limb deficiencies. 4 patients had "longitudinal distal radial deficiencies" types 1, 2, 4 and 5. This deformity probably occurs in 1 of 100,000 live births. In a previous study, we found 23 children with longitudinal radial defect in a group of 79 children with upper limb deficiencies (Thomsen et al. 1998).

1 patient showed "longitudinal combined humero-ulna deficiencies" types 2 and 3 of both arms (Henkel et al. 1978). Sprengel's deformity was diagnosed in 15 cases, but none in combination with an upper limb deficiency.

The underlying mechanism leading to the concurrence of anomalies is probably due to in the pattern of embryonic development of the scapula which takes place in the 3rd week of gestation. It descends to its normal (thoracic) position by the 8th week. In Sprengel's anomaly, the normal descent is thought to be impaired, causing a displacement of the scapula. The Klippel-Feil lesion is thought to occur during weeks 3–8 of gestation (Hensinger et al. 1974). The combination of Klippel-Feil syndrome and upper limb deficiency shortens the time for development of the defect to the 4th–5th week.

In our study, it was mainly sclerotome 6 that was affected, as compared to the 98% in the study of McCredie and Willert (1999). According to their sclerotome theory we found a perfect matching (grade 1) only twice. We saw 4 less obvious or an uncertain match with the sclerotomes (grade 2) and 1 patient in whom the longitudinal defect coincided poorly (grade 3), whereas McCredie and Willert (1999) mainly found grade 1 (73.5%). If we combine grades 1 and 2, the results of our study and the large study of McCredie and Willert (1999) are similar.

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