Split hand/split foot deformity and LADD syndrome in a family: overlap between the EEC and LADD syndromes

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Abstract
A mother and daughter are reported with apparently dissimilar syndromes. The mother has a split hand/split foot deformity and the daughter a condition consistent with a diagnosis of LADD syndrome. Absence of clefting and deficient formation of saliva and tears are the main signs that differentiate the LADD from the EEC syndrome. However, no distinct feature is constant between these two autosomal dominant disorders that show great phenotypic variability. This report emphasises the overlap between the LADD and the EEC syndromes.

The lacrimo-auriculo-dento-digital (LADD) syndrome is an autosomal dominant disorder characterised by hypoplasia or aplasia of the lacrimal and salivary tract, dysplastic ears with cup shaped pinnae, sensorineural deafness, dental abnormalities, and limb defects predominantly on the radial border of the hands. Renal abnormalities have also been documented. The ectrodactyly-ectodermal dysplasia-clefting (EEC) syndrome is another autosomal dominant condition with great variability in expression and penetrance. Absent lacrimal puncta, conductive hearing loss, deformed ears, and dental abnormalities have also been documented in the EEC syndrome, leading Hennekam to suggest that the same pleiotropic gene could cause the LADD syndrome and the EEC syndrome and that these two syndromes are extremes of the same autosomal dominant condition. We report on a family with ectrodactyly and LADD syndrome that emphasises the overlap between these two disorders.

Case reports

CASE 1
The proband, a Caucasian female, was referred to the Genetic Clinic because of poor growth and mental retardation. She was born at term after an uneventful pregnancy and delivery. Birth weight was 2500 g, length 45 cm, and head circumference (OFC) 31 cm. Motor development was delayed from birth. She was treated for bilaterally dislocated hips.

At 22 months, weight (6600 g), height (71 cm), and OFC (42.5 cm) were below the 3rd centile. Psychomotor development was severely delayed. She had no speech and was rated at an 8 month old level on the 'Termann-Merill' scale. On examination, the ears were bilaterally low set, posteriorly rotated, and small with downward folded helices (fig 1). The deciduous teeth were poorly implanted with hypoplastic lower incisors and canines and peg shaped upper lateral incisors (fig 2). The child exhibited minor facial dysmorphic features including a bulbous nasal tip and flared nostrils. Clinical examination and his-

Figure 1  Case 1, side view. Note low set and posteriorly rotated ears and bulbous nasal tip.

Figure 2  Poor implantation of deciduous teeth of case 1.
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A Figure 3 (A) Feet of case 1 showing partial duplication of the big toes and syndactyly between the left 2nd and 3rd toes and 4th and 5th toes. (B) X ray examination of the right foot showing duplication of the hallux.

The proband had the lacrimal, auricular, and dental abnormalities of the LADD syndrome. She had broad bifid halluces and syndactyly of the toes with minimal upper limb involvement. Radial ray defects in the upper limbs are well documented in the LADD syndrome, including bifid, finger-like, or hypoplastic thumb, and hypoplasia of the thenar eminence. Various other digital abnormalities have been reported, such as syndactyly of the

Discussion
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second and third digits, shortened fingers with broad distal phalanges, distal tapering, fifth finger clinodactyly, and a large interdigital cleft between the second and third fingers. Upper limb malformations seem to be the most variable features of the LADD syndrome. Some families have been described with only mild clinodactyly of the fifth fingers on x-ray, or with no hand abnormalities. Lower limbs are generally normal in the LADD syndrome, but syndactyly of the second and third toes and broad halluces have been reported. A recent report emphasized the lower limb involvement in a family with broad, large halluces and narrow nails. The broad, bifid halluces of our proband are unexpected, but seem to represent the more severe end of the spectrum of large halluces. Some reported patients with split hand malformation and EEC syndrome show foot abnormalities (syndactyly of toes, duplicated halluces) that are strikingly similar to case 1.

Robinson et al. described a family in which the proband had malformed ears, bilateral deafness, hypodontia and peg shaped incisors, a short middle finger on one hand, bilateral syndactyly of the third and fourth fingers, and bilateral absence of the middle phalanges of the feet, suggesting a diagnosis of LADD syndrome. However, his two great uncles had a split foot deformity and cleft lip and palate, and his mother had syndactyly of the hands and feet, cleft lip and palate, hypodontia, and conductive hearing loss, so the authors concluded that this family had EEC syndrome and hearing loss. This family and our report, show overlap between the EEC and LADD syndromes. Temtamy and McKusick had already reported great variability in the familial transmission of abnormalities of the extremities in the EEC syndrome, ranging from mild campodactyly of the fifth fingers to split hand/split foot deformity in the same family in association with absent helix. Wiegmann and Walker described a family with chronic dacrocystitis, absence or early loss of teeth, and split hand/split foot without other ectodermal abnormalities or clefts.

About 90% of patients with EEC syndrome have absent lacrimal puncta and about 30% have conductive hearing loss. Congenitally missing permanent teeth, coniform teeth, and enamel dysplasia are common. All features of the LADD syndrome have been described in EEC syndrome families, but cleft lip palate has been reported in only 75% of cases of EEC syndrome. Preus and Fraser have argued that cleft lip/palate may not be an essential part of the EEC syndrome. Küster et al. have emphasized the fact that ectodactyly is not an obligate symptom of the EEC syndrome. Hypopigmentation of the skin and hair has been noted in most white patients, but black patients have normal pigmentation. Chromosomally normal infants have been found to be the great phenotypic variability in the EEC syndrome: none of the affected members of this family had the same pattern of abnormalities. Genitourinary malformations are documented in the LADD syndrome and in at least 20% of cases of EEC syndrome. Microcephaly and mental retardation have been reported in about 10% of cases of the EEC syndrome, but not in the LADD syndrome. The mental status of case 1 could have been affected because of the failure to treat the deafness. Early recognition of the LADD and EEC syndromes is important because of the possibility that the affected infant may have a hearing disorder.

Case 2 is consistent with partial expression of the EEC syndrome. The family described increases the phenotypic variation in these two autosomal dominant disorders and emphasizes the overlap between these two syndromes. Whether LADD and EEC syndromes represent allelic forms of the same gene or contiguous gene syndromes will have to be left to future studies and the mapping of a potential gene. Recent advances in the molecular embryology of the developing limb bud have identified some candidate morphogens for limb defects such as retinoid metabolism or receptors. Six cases of interstitial 7(q21 or 22) deletions and four cases of apparently balanced chromosomal rearrangements with breakpoints at 7(q21 or 22), each exhibiting ectodactyly (and sometimes additional features of the EEC syndrome), suggest two loci in 7q22 near to the proximal interface for limb differentiation. On the other hand, there are 17 additional deletions involving this band but not associated with ectodactyly. Genetic interactions such as position effect and unmasking heterozygosity, and extreme variability in the expression of ectodactyly could explain this discrepancy. Quamshie believes that the critical region for the EEC syndrome is at 7q1.2-q21.3. The breakpoints reported in the different deletions or translocations can be determined by using the alkphorose sequences available for chromosome 7. DNA analysis now offers the prospect of identifying the gene. Linkage analysis of families with genetically inherited limb defects (EEC or LADD syndromes) will provide answers concerning genetic heterogeneity.
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