Cleidocranial dysplasia (CCD) is a rare skeletal disorder with delayed osteoblast differentiation and autosomal dominant inheritance caused by mutations in the RUNX2 gene (1,2). The main clinical features include short stature, hypoplastic or aplastic clavicles, delayed ossification of calvaria, multiple Wormian bones, wide forehead, midface hypoplasia and dental anomalies; including supernumerary teeth and severely delayed or arrested tooth eruption (1,3). Kreiborg et al. (4) suggested, based on radiographic findings of altered surface remodelling of the jaws that osteoclast differentiation and function are also affected, and Yoda et al. (5) and Lossdörfer et al. (6) found that impaired recruitment of osteoclasts is one of the mechanisms of delay or lack of tooth eruption in CCD.

Jensen & Kreiborg (7) reported that the primary dentition is fairly normal in CCD, except for a slightly delayed eruption, whereas the permanent dentition is characterized by severe anomalies in tooth formation, maturation and eruption. All but one, of 18 cases evaluated by these authors had
supernumerary permanent teeth, and two subjects developed a nearly complete supernumerary dentition mesial to the first molars. The supernumerary teeth developed lingually and occlusally to the normal teeth, and their maturation was delayed about 4 years compared to the normal teeth. All subjects had disturbances of eruption in the permanent dentition; both in regions with and without supernumerary teeth. The authors suggested that the supernumerary teeth mesial to the first molars represent a more or less complete 3rd dentition; that supernumerary molars develop through a repeating mechanism of normal molar development; and that the supernumerary teeth develop from remnants of the dental lamina, which have not been dissolved at the expected time. They concluded that the intraosseous stage of permanent tooth eruption is hampered in at least two ways in CCD:

1) If a supernumerary tooth develops in a given region, it forms occlusally to the normal tooth at the time when the intraosseous stage of eruption of the normal tooth should start and, thus, hinders eruption of the normal tooth.

2) The resorption of alveolar bone and primary teeth is severely delayed, even in regions without supernumerary teeth, because of insufficient osteoclast activity.

Based on these biological principles, Jensen & Kreiborg (8) suggested the following interceptive treatment strategies in CCD to promote spontaneous tooth eruption:

1) Early diagnosis of supernumerary teeth; supernumerary incisors can be expected to be diagnosed radiographically from 5-6 years of age and canines and premolars a couple of years later.

2) In regions with supernumerary teeth: removal of primary teeth, supernumerary teeth and overlying bone at the time when the roots of the normal teeth have reached about half of their final length.

3) In regions without supernumerary teeth: removal of primary teeth and overlying bone at the time when the roots of the normal teeth have reached about half of their final length.

4) Orthodontic treatment; if necessary, combined with autotransplantation of teeth, dental implants and orthognathic surgery.

This case report will illustrate the application of these treatment strategies and document the outcome of treatment.

Case study
A boy with CCD was followed from infancy till adulthood. He is the son of a woman with CCD who had previously been treated by us. CCD was observed in three generations, and all affected family members have a heterozygous deletion in the RUNX2 gene (c.1121delG). The boy was diagnosed at birth because of severely delayed ossification of the calvaria and hypoplastic clavicles. He was followed clinically from 5 months of age to the age of 19 years. From 4.5 years of age the examinations were supplemented with annual intraoral photographs (Fig. 1), orthopantomographic x-rays (Fig. 2) and cephalometric x-rays (Fig. 3) to monitor dental and craniofacial development. This report will focus on the dental development.

Dental development
Primary dentition – The lower incisors started to erupt at 7 months of age. By 1.7 years all incisors had erupted and the canines had penetrated the oral mucosa. The second molars were relatively late to show signs of eruption, but at 4.5 years all molars were fully erupted and occlusion was normal (Fig. 1A).

Permanent dentition – At 5.5 years all teeth could be observed in the panoramic x-ray. No supernumerary teeth were seen at this age. However, the dentition was 9-12 months delayed in maturity compared to normative data (Fig. 2A).

Two supernumerary lower incisors were diagnosed at 6.7 years, and at 7.5 years a supernumerary tooth developed in the upper incisor region. No treatment was carried out at this stage, because of delayed root formation of the normal incisors. All first molars erupted spontaneously, but with a delay of about 2.5 years (Fig. 2B). At 9.5 years, all lower primary incisors were extracted, and the supernumerary lower incisors and overlying bone covering the permanent incisors were removed. At 10.2 years of age, all
Upper primary incisors had been extracted; the supernumerary upper incisor had been removed, and the upper permanent incisors had been surgically exposed. The panoramic x-ray revealed that two supernumerary upper canines had developed. In addition, the upper second premolars were in an ectopic position, and the lower, left second molar had a mesioangular position. Dental maturation was, in general, delayed by 1½-2 years compared to normative data (Fig. 2C). The lower incisors were in spontaneous eruption at this stage (Fig. 1B). At 10.8 years, all permanent incisors were in spontaneous eruption (Fig. 1C).

About one year later, the upper primary canines were extracted, the supernumerary canines were removed and surgical exposure of the normal canines was carried out. At 12.2 years, the lower, left second premolar had erupted spontaneously, whereas none of the remaining teeth showed signs of spontaneous eruption at this stage (Fig. 1B). At 10.8 years, all permanent incisors were in spontaneous eruption (Fig. 1C).

Discussion and conclusions
The primary dentition was normal and all teeth erupted spontaneously. Similar findings were previously reported by Jensen & Kreiborg (7). The reason for spontaneous eruption of primary teeth is probably that these teeth are only covered by a thin layer of bone; the need for osteoclastic activity in connection with eruption is thus minimal.

Five supernumerary permanent teeth were diagnosed in the incisor and upper canine regions. The teeth were positioned lingually and occlusally to the normal teeth and were delayed about 4 years in maturation compared to the normal permanent teeth. These findings are in agreement with previous observations by Jensen & Kreiborg (7). The normal teeth were also somewhat delayed in maturation, and this finding is in agreement with several previous studies (7,9,10). Tooth eruption was delayed both in regions with and without supernumerary teeth. This finding is also in agreement with previous observations (7). The supernumerary teeth obstruct the eruption path of the normal teeth which leads to arrested eruption, and diminished osteoclastic activity is probably the cause of delayed tooth eruption in regions without supernumerary teeth (5,6). However, all first molars erupted spontaneously, although with a delay of about 2.5 years. Similar findings have previously been reported (7,9,10). The delay in eruption could mainly be explained by delayed maturation of these teeth. The fact that the teeth did not erupt to open space for the upper second premolars; these teeth were surgically exposed and orthodontic traction was applied. The upper second molars remained impacted. The orthodontic treatment was completed with an acceptable aesthetic and functional result (Figs. 1D and 2F).
erupt spontaneously can probably be explained by the superfi-
cial position of these tooth buds in the jaws with limited bone
coverage and lack of primary predecessors.

In general, the interceptive treatment strategies suggested
by Jensen & Kreiborg (8), based on biological principles, were
employed in the present case and lead to spontaneous eruption,
although with delay, of all teeth mesial to the first molars, ex-
cept for ectopic upper second premolars. However, these teeth
responded well to orthodontic traction.

In conclusion, the treatment strategies used aimed at pro-
moting spontaneous tooth eruption and were found to work
well in the present case. These findings contradict the state-
ment of D’Alessandro et al. (11) that natural eruption fails to
occur in CCD.

Although our patient had several surgical procedures, these
were all relatively minor. Furthermore, the corrective ortho-
dontic treatment period was short since nearly all teeth erupted
spontaneously. Thus, the burden of care would seem to be less
than with the more aggressive corrective treatment approach-
es, currently advocated in the literature, with surgical exposure
of nearly all permanent teeth and application of active ortho-
dontic traction (9,10,12,13).

ABSTRACT (DANSK)

Cleidocranial dysplasia – interceptive Behandlmg af forstyrrelser
af tandfrembrud

Baggrund – Formålet med den foreliggende rapport var at re-
degere for behandlingsforløbet hos en dreng med cleidocranial
dysplasia (CCD) behandlet i henhold til den interceptive strategi,
der tidligere er blevet foreslået af Jensen og Kreiborg.

Patienttilfælde – Drengen blev fulgt fra den helt tidlige barndom
til voksen alder med kliniske undersøgelser, fotografier samt or-
topantomografiske og cefalometriske røntgenundersøgelser for
t at monitorere den kraniofaciale og dentale udvikling og behand-
lingsforløbet. Den primære dentition var normal. Den permanente
dentition viste afvigelser i relation til såvel tandmodenhed som
tandmodenhed og eruption. Drengen udvikledes fem overalt-
tønder og havde alvorlige problemer med eruptionen af næsten
samtlige normale tænder. Det generelle behandlingsprincip var at
fremme spontan eruption ved at fjerne overaltværende tænder, primæ-
re tænder og knogle, der dækker de normale permanente tænder
på det tidspunkt, hvor disse tænder har udviklet omkring halvde-len af deres endelige rodlængde. Næsten alle tænder erupterede
herefter spontant, og behovet for korrektiv ortodontisk behand-
ling blev derved begrænset til en relativt kort periode.

Konklusion – Undersøgelsens resultater støttet forslaget om, at
patienter med CCD kan behandles interceptivt ved fjernelse af
hindringerne for normal tanderuption (overaltværende tænder, primære
tænder og alveoler knogle) på det tidspunkt, hvor de normale
permanente tænder har udviklet omkring halvden af deres en-
delige rodlængde.

CLINICAL RELEVANCE

The current case report sup-
ports the interceptive dental
treatment strategies in
Cleidocranial dysplasia pre-
viously suggested to promote
spontaneous eruption of
permanent teeth. The strate-
gies seem to result in a less
dramatic treatment for the
patient and less complicated
procedures for the dentist
with a shorter total active
treatment time compared to
the corrective treatment stra-
tegies currently advocated in
the literature.

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