Klippel-Feil Syndrome (KFS) is a rare congenital disorder characterized by the abnormal fusion of two or more cervical vertebrae. This fusion can lead to a variety of skeletal, neurological, and vascular issues due to the restricted movement of the neck and misalignment of the spinal column. The syndrome was first described by Maurice Klippel and André Feil in 1912.

Key Features of Klippel-Feil Syndrome:

1. **Triad of Classic Symptoms**:

```
 The classic clinical presentation of KFS includes the following:
 - **Short neck**: Due to the fusion of cervical vertebrae.
 - **Low posterior hairline**: The hairline appears lower than usual on the back of the neck.
 - **Restricted neck movement**: Limited range of motion in the neck, particularly in flexion and extension, due to vertebral fusion.
```

```
 Not all individuals with KFS exhibit all three classic symptoms, and the severity can vary widely.
```

2. **Classification of Klippel-Feil Syndrome**:

1. **Type I**: Extensive fusion of cervical and thoracic vertebrae.
2. **Type II**: Fusion of one or two vertebrae, often associated with other spinal abnormalities.
3. **Type III**: Fusion of cervical vertebrae with additional thoracic or lumbar anomalies.

3. **Associated Anomalies**:

```
 KFS is often associated with other congenital abnormalities, affecting multiple systems:
 - **Skeletal anomalies**: Scoliosis (curvature of the spine), Sprengel’s deformity (elevation of the shoulder blade), and rib anomalies.
 - **Neurological issues**: Due to the proximity of fused vertebrae to the spinal cord, some patients may experience neurological symptoms such as weakness, numbness, or coordination problems. In severe cases, there may be spinal cord compression.
 - **Renal (kidney) abnormalities**: Renal agenesis (absence of one kidney), horseshoe kidney, or other urinary tract malformations.
 - **Cardiovascular defects**: Congenital heart defects, such as ventricular septal defects, have been reported in patients with KFS.
 - **Hearing loss**: Conductive or sensorineural hearing loss is common due to middle or inner ear abnormalities.
```

4. **Causes**:

1. KFS occurs due to failure of the normal segmentation of the cervical vertebrae during embryonic development. It is believed to result from genetic mutations or environmental factors, although the exact cause is not fully understood.
2. Several genes, such as **GDF6**, **GDF3**, and **MEOX1**, have been implicated in cases of KFS, indicating a possible genetic basis for the syndrome in some individuals.

5. **Diagnosis**:

1. **X-rays**: Can reveal the extent of vertebral fusion and other skeletal abnormalities.
2. **MRI or CT scans**: Provide detailed images to assess for spinal cord involvement or more complex bone deformities.
3. **Ultrasound or other imaging**: May be used to evaluate associated abnormalities, particularly of the kidneys or heart.

6. **Treatment**:

1. **Conservative management**: In cases where the fusion is not causing significant neurological problems or spinal deformities, treatment may involve physical therapy to manage pain and improve neck mobility.
2. **Surgical intervention**: Surgery may be necessary for individuals with severe deformities, spinal cord compression, or instability of the cervical spine. Common procedures include spinal fusion or decompression to relieve pressure on the spinal cord.
3. **Management of associated conditions**: Cardiac, renal, or hearing abnormalities may require specific interventions depending on their severity.

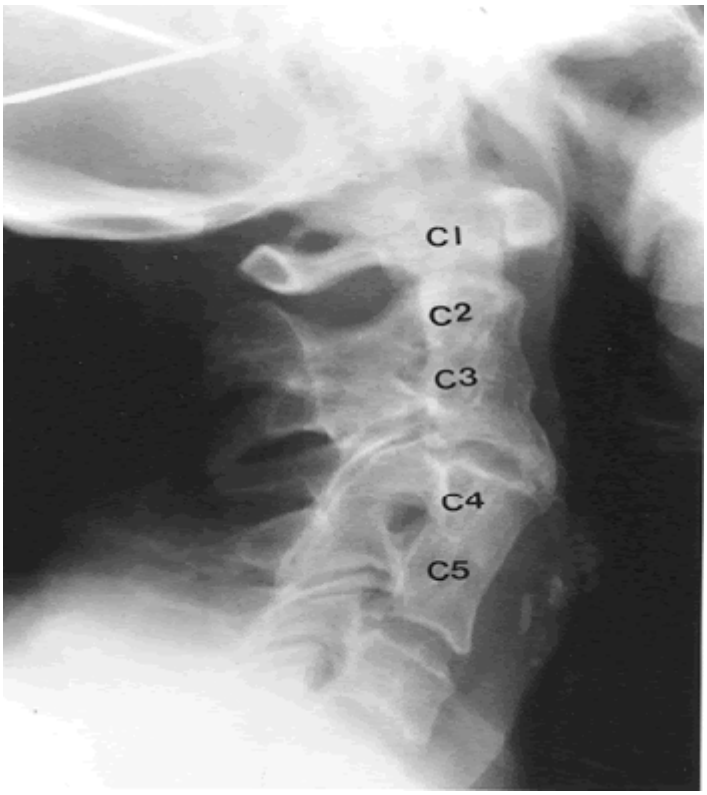
7. **Prognosis**:

1. The prognosis for KFS depends on the severity of the vertebral fusion and any associated abnormalities. Some individuals live with minimal symptoms, while others may experience complications like chronic pain, limited mobility, or neurological impairment.
2. Long-term monitoring is often required to detect complications such as scoliosis progression, spinal cord issues, or the development of degenerative joint disease in the cervical spine.

Complications: - **Scoliosis**: The abnormal curvature of the spine is common in KFS and may require bracing or surgery if severe. - **Neurological deficits**: Spinal cord compression due to vertebral fusion can result in weakness, sensory loss, or coordination problems. - **Degenerative arthritis**: The fused cervical spine is at higher risk for early degenerative changes, which can lead to chronic pain and stiffness. - **Vascular anomalies**: Abnormal blood vessel formation can occur, leading to complications such as stroke or vascular insufficiency.

Klippel-Feil Syndrome is a complex disorder that requires a multidisciplinary approach to treatment, including orthopedic, neurological, and sometimes cardiac or renal care. Early diagnosis and appropriate management are key to improving outcomes and preventing long-term complications.

Klippel Feil syndrome is a rare disease, initially reported in 1912 by Maurice Klippel and André Feil from France, characterized by the congenital fusion of any 2 of the 7 cervical vertebrae.



Congenital fusion of two or more cervical vertebrae. Ranges from the fusion of only the bodies (congenital block vertebrae) to fusion of the entire vertebrae (including posterior elements). Results from failure of normal segmentation of cervical somites between 3 and 8 weeks' gestation. Involved vertebral bodies are often flattened, and associated disc spaces are absent or hypoplastic. Hemivertebrae may also occur. Neural foramina are smaller than normal and oval. Cervical stenosis is rare. The complete absence of the posterior elements with an enlarged foramen magnum and fixed hyperextension posture is called iniencephaly and is rare. The incidence of Klippel-Feil is unknown due to its rarity and the fact that it is frequently asymptomatic.

May occur in conjunction with other congenital cervical spine anomalies such as basilar impression and atlantooccipital fusion.

Classification

Samartzis classification

Type I Having a single congenitally fused cervical segment.

Type II Multiple noncontiguous, congenitally fused segments.

Type III Multiple contiguous, congenitally fused cervical segments [1)]

Type I: mass fusion of C-spine to upper T-spine

Type II: fusion of only 1 or 2 interspaces

Clinical features

Classic clinical triad (all 3 are present in < 50%):

1. low posterior hairline

2. shortened neck (brevicollis)

3. limitation of neck motion (may not be evident if < 3 vertebrae are fused, if fusion is limited only to the lower cervical levels, or if hypermobility of nonfused segments compensates). Limitation of movement is more common in rotation than flexion-extension or lateral bending

Other clinical associations include scoliosis in 60%, facial asymmetry, torticollis, webbing of the neck (called pterygium colli when severe), Sprengel's deformity in 25–35% (raised scapula due to failure of the scapula to properly descend from its region of formation high in the neck to its normal position about the same time as the Klippel-Feil lesion occurs), synkinesis (mirror motions, primarily of hands but occasionally arms also), and less commonly facial nerve palsy, ptosis, cleft or high arched palate. Systemic congenital abnormalities may also occur, including genitourinary (the most frequent being a unilateral absence of a kidney), cardiopulmonary, CNS, and deafness in ≈ 30% (due to defective development of the osseous inner ear).

No neurologic symptoms have ever been directly attributed to the fused vertebrae, however, symptoms may occur from nonfused segments (less common in short-segment fusions) which may be hypermobile, possibly leading to instability or degenerative arthritic changes.

The syndrome occurs in a heterogeneous group of patients unified only by the presence of a congenital defect in the formation or segmentation of the cervical spine. Klippel–Feil syndrome can be identified by shortness of the neck. Those with the syndrome have a very low hairline and the ability of the neck to move is limited.

Treatment

Usually directed at detecting and managing the associated systemic anomalies. Patients should have a cardiac evaluation (EKG), CXR, and renal ultrasound. Serial examinations with lateral flexion-extension C-spine X-rays to monitor for instability. Occasionally, a judicious fusion of an unstable non-fused segment may be needed at the risk of further loss of mobility.

In patients with KFS with basilar invagination (BI), compression of the brainstem and upper cervical cord results in neurological deficits, and decompression and occipitocervical reconstruction are required. The highly varied anatomy of KFS makes a posterior occipitocervical fixation strategy challenging. For these patients, the transoral atlantoaxial reduction plate (TARP) operation is an optimal option to perform a direct anterior fixation to achieve stabilization [2)].

Contraindications for participation in contact sports except associated with full ROM without occipitocervical anomalies, instability, disc disease absolute or degenerative changes

Outcome

In the series Patel et al. the patients who pursued surgical treatment reported significantly more comorbidities ($p = 0.02$) and neurological symptoms ($p = 0.01$) than nonsurgically treated participants and were significantly older when pain worsened ($p = 0.03$), but there was no difference in levels of muscle, joint, or nerve pain ($p = 0.32$); headache/migraine pain ($p = 0.35$); total number of cervical fusions ($p = 0.77$); location of fusions; or age at pain onset ($p = 0.16$).

More than 90% of participants experienced pain. Participants with an increased number of overall cervical fusions or multilevel, contiguous fusions reported greater levels of muscle, joint, and nerve pain. Participants who pursued surgery had more comorbidities and neurological symptoms, such as balance and gait disturbances, but did not report more significant pain than nonsurgically treated participants [3].

Case series

Seventy-five patients (60 female, 14 male, and 1 unknown) were identified and classified as having the following types of Samartzis fusion: type I, n = 21 (28%); type II, n = 15 (20%); type III, n = 39 (52%). Seventy participants (93.3%) experienced pain associated with their KFS. The median age of patients at pain onset was 16.0 years (IQR 6.75-24.0 years), and the median age when pain worsened was 28.0 years (IQR 15.25-41.5 years). Muscle, joint, and nerve pain was primarily located in the shoulders/upper back (76%), neck (72%), and back of head (50.7%) and was characterized as tightness (73%), dull/aching (67%), and tingling/pins and needles (49%). Type III fusions were significantly associated with greater nerve pain ($p = 0.02$), headache/migraine pain ($p = 0.02$), and joint pain ($p = 0.03$) compared to other types of fusion. Patients with cervical fusions in the middle region (C2-6) tended to report greater muscle, joint, and nerve pain ($p = 0.06$). Participants rated the effectiveness of oral over-the-counter medications as 3 of 5 (IQR 1-3), oral prescribed medications as 3 of 5 (IQR 2-4), injections as 2 of 5 (IQR 1-4), and surgery as 3 of 5 (IQR 1-4), with 0 indicating the least pain relief and 5 the most pain relief. Participants who pursued surgical treatment reported significantly more comorbidities ($p = 0.02$) and neurological symptoms ($p = 0.01$) than nonsurgically treated participants and were significantly older when pain worsened ($p = 0.03$), but there was no difference in levels of muscle, joint, or nerve pain ($p = 0.32$); headache/migraine pain ($p = 0.35$); total number of cervical fusions ($p = 0.77$); location of fusions; or age at pain onset ($p = 0.16$).

More than 90% of participants experienced pain. Participants with an increased number of overall cervical fusions or multilevel, contiguous fusions reported greater levels of muscle, joint, and nerve pain. Participants who pursued surgery had more comorbidities and neurological symptoms, such as balance and gait disturbances, but did not report more significant pain than nonsurgically treated participants [4].

Case reports

Abdali et al. reported a child with an extremely rare association of KFS with situs inversus totalis (SIT).

Both KFS and SIT are genetically heterogeneous and their co-occurrence suggests a high possibility of sharing the same underlying causative agent. They reviewed the genetic background that is known for these two conditions in the literature. [5].

References

[1]
Samartzis DD, Herman J, Lubicky JP, Shen FH. Classification of congenitally fused cervical patterns in Klippel-Feil patients: epidemiology and role in the development of cervical spine-related symptoms. Spine (Phila Pa 1976). 2006 Oct 1;31(21):E798-804. PubMed PMID: 17023841.

[2]
Wei G, Wang Z, Ai F, Yin Q, Wu Z, Ma XY, Xu J, Shi C, Xia H. Treatment of Basilar Invagination With Klippel-Feil Syndrome: Atlantoaxial Joint Distraction and Fixation With Transoral Atlantoaxial Reduction Plate. Neurosurgery. 2016 Apr;78(4):492-8. doi: 10.1227/NEU.0000000000001094. PubMed PMID: 26990409.

[3] [4]
Patel K, Evans H, Sommaruga S, Vayssiere P, Qureshi T, Kolb L, Fehlings MG, Cheng JS, Tessitore E, Schaller K, Nouri A. Characteristics and management of pain in patients with Klippel-Feil syndrome: analysis of a global patient-reported registry. J Neurosurg Spine. 2019 Dec 13:1-6. doi: 10.3171/2019.9.SPINE19820. [Epub ahead of print] PubMed PMID: 31835254.

[5]
Abdali HA, Duddu JR, Mubarak MJ, Mohamed AS. Rare association of Klippel-Feil syndrome with situs inversus totalis and review of the genetic background. BMJ Case Rep. 2021 May 12;14(5):e241906. doi: 10.1136/bcr-2021-241906. PMID: 33980560.