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Original Article

Fractures of the occipital condyle clinical spectrum and course in eight patients

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Abstract

Introduction: Occipital condyle fractures (OCFs) are considered to be rare injuries. OCFs are now diagnosed more often because of the widespread use of computed tomography. Our aim is to report the incidence, treatment and long term outcome of 8 patients with OCFs. **Materials and Methods:** All patients presenting with multiple trauma from 1993 to 2006 were analyzed retrospectively. Characteristics and course of the treatment were evaluated. Follow-up was performed after 11,7 years (range 5,9 to 19,3 years). **Results:** Nine cases of OCF in 8 patients were identified. All injuries resulted from high velocity trauma. The average scores on the ISS Scale were 39,6 (24-75) and 7,3 (3-15) on the GCS. According to Anderson's classification, 5 cases of Type III and 4 cases of Type I fractures were identified. According to Tuli's classification, 5 cases of Type IIA and 4 cases of Type I were found. Indications for immobilization with the halo-vest were type III injuries according to Anderson's classification or Tuli's type IIA injuries, respectively. Patients with Tuli's type I injuries were treated with a Philadelphia collar for 6 weeks. In one patient with initial complete tetraplegia and one with incomplete neurological deficits the final follow-up neurologic examination showed no neurological impairment at all (Frankel-grade A to E, respectively B to E). At follow-up, 3 patients were asymptomatic. Four patients suffered from mild pain when turning their head, pain medication was necessary in one case only. **Discussion:** OCF`s are virtually undetectable using conventional radiography. In cases of high velocity, cranio-cervical trauma or impaired consciousness, high resolution CT-scans of the craniocervical junction must be performed. We suggest immobilization using a halo device for type III injuries according to Anderson's classification or Tuli's type IIa injuries, respectively. Patients with Tuli's type I injuries should be treated with a Philadelphia collar.

Key words: Long-term outcome, multiple trauma, occipital condyle fracture

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INTRODUCTION

Fractures of the occipital condyle are considered to be rare injuries in the international literature. The initial reports came from autopsy series.[1-3] The great majority of publications about clinical cases are case reports. In most of these cases, the cause is a high-speed traffic accident.[4] Frequently, diagnosis was delayed until after neurological deficits appeared in cranial nerves, prompting more accurate imaging examinations. In the literature, there are increasing numbers of reports that include larger numbers of cases.[5,6] One prospective study reported about 31 cases.[4] The incidence of occipital condyle fractures in severely injured patients has been reported at between 1% and 2% respectively.[4,6,7]

We are assuming that this injury is frequently missed and is thus significantly underreported. Due to increasing numbers of high-speed traffic accidents and improved pre-hospital emergency care, we are witnessing an increase in the incidence of this injury in our own clinical population. Due to severe concomitant injuries that require priority treatment, it is easy to overlook this injury. Delayed diagnosis can result in permanent neurological damage, even including quadriplegia.

It is rarely possible to diagnose occipital condyle fractures on conventional X-ray images. Computer tomography (CT) with imaging of the craniocervical junction is absolutely essential for making the diagnosis. That can be the reason, why increasing cases are described since the beginning of CT diagnostic.[4,8] Due to the small overall case numbers, there are no evidence-based treatment recommendations. Treatment options range from a soft cervical collar to cranio-cervical fusion surgery.

The goal of this retrospective study was to characterize our patient collective and to discover common features. In addition, we would like to control our treatment concept and long-term results for this rare injury.

We are reporting about the clinical spectrum, treatment and findings on follow-up examination in 8 patients with fractures of the occipital condyle.

MATERIALS AND METHODS

We performed a search for patients treated in our department for occipital condyle fractures. To this end, we conducted a retrospective search of all operative reports, charts of the multiple injured patients and records of patients treated in the intensive care unit between 1993 and 2006. A total of 8 patients were identified and the clinical histories were collected for all patients. All fractures were classified both according to Anderson and Montesano's classification and Tuli's classification. We opted to use both classifications, since the Anderson and Montesano's classification had been the one most commonly used up to 1997.

Classification

The first classification system was proposed by Saternus and Thrun[3] in 1987 based upon autopsy findings and was included 6 types. This classification was never incorporated into clinical practice.

The most commonly employed clinical classification is the division into three types proposed by Anderson and Montesano[9] [Table 1].

Type I

Type I represents a compression fracture resulting from an axial force, comparable to the mechanism in a classical Jefferson fracture. Morphologically, it involves impaction of the fragments accompanied by only slight displacement. Comminuted fractures are possible. This fracture is considered to be stable, since although the ipsilateral alar ligament may be functionally inadequate, the contralateral alar ligament and the tectorial membrane remain intact.

Type II

Type II occurs in the context of a basilar skull fracture, where the fracture extends medially from the parietal bone to the foramen magnum, thereby traversing an occipital condyle. This fracture type is also considered to be stable, since both alar ligaments as well as the tectorial membrane remain intact. The fracture mechanism is attributed to lateral skull compression. If the fracture radiates to the hypoglossal canal, hypoglossal nerve lesions may occur.

Type III

Type III fractures involve shearing or avulsion injuries to one or both occipital condyles. The bony fragment can be displaced medially along the course of the alar ligament to the apex of the dens. Causes for this injury are rotation, lateral inclination or a combination of both. Distraction may also be the mechanism of the injury. These injuries are considered unstable, since the alar ligament hanging from the fractured occipital condyle is structurally insufficient and both the tectorial membrane and the contralateral alar ligament may also be torn. The lower portion of the clivus may likewise be injured concomitantly.

Tuli *et al.*[10] [Table 2] propose a classification system based upon the degree of dislocation. In our opinion, this classification seems best suited for treatment planning.

In Type I, there are non-dislocated fractures present and thus this type is considered as stable.

In Type II, the fragments are dislocated.

Table 1: Fracture classification according to Anderson and Montesano

Type	Description	Stability
I	Impacted fracture	Axial stress, stability from the contralateral alar ligament and tectorial membrane
II	Fracture of the base of the skull extending into the condyle	Stability from the intact alar ligament and tectorial membrane
III	Avulsion fracture	Tear of the bony attachment of the alar ligament. Instability due to associated injuries of the tectorial membrane

Table 2: Fracture classification according to Tuli *et al.*

Type	Description	Stability
I	Not displaced (<2 mm)	Stable
IIa	Displaced without AOD	Stable
IIb	Displaced with AOD	Unstable

AOD: Atlanto-occipital dislocation

Type II is further subdivided into:

Type IIa, when no additional ligamentous injuries or atlanto-occipital instability are present. Type IIa may also be classified as stable.

In Type IIb, there are additional ligamentous injuries or atlanto-occipital instability. This injury is considered as unstable.

Treatment based on the classification

The indication for immobilization using a halo fixation device was the presence of Type III injuries on the Anderson scale or Type IIa injuries on the Tuli scale [Tables 1 and 2]. The patients with Type I injuries on the Tuli scale wore a Philadelphia cervical collar for 6 weeks.

For elicit the severity of the patient's overall injuries, we determined the injury severity score (ISS). In addition, the severity of the head injury was assessed by means of the Glasgow coma scale (GCS) as well as the Frankel neurological classification.

All surviving patients were given a clinical follow-up examination ranging from 14 month to 10 years. A standardized interview via telephone was performed after 11.7 years (range 5.9-19.3 years). Subjective satisfaction with treatment results, range of movement, pain at rest and under strain, pain medications and the Hannover Spinal Trauma Score were all determined. For dislocated fractures, CT of the craniocervical junction was performed at the time of follow-up examination. To assess stability, there was an additional dynamic examination conducted under the image intensifier.

RESULTS

Between 1993 and 2006, a total of approximately 34,500 patients were admitted to the hospital. There were altogether 34,500 operations performed on 25,200 patients. A total of 1,800 patients were treated in the intensive care unit, among them 700 with multiple trauma. Out of this patient collective, we identified 8 patients with occipital condyle fractures.

Table 3 provides an overview of the patient collective: All of the patients were male. Their average age was 24 (16-45) years. The mechanism of injury in seven cases was a motor vehicle accident. Six patients were passengers in an automobile involved in a high-speed accident. In two cases, fellow travelers died at the scene of the accident. One patient was struck by a fast-moving automobile while lying on the street. The eighth patient was struck by a falling tree while working as an arborist.

All of the patients had severe concomitant injuries [Figure 1]. The average ISS was 37 (24-57) [Table 3]. In nearly all of the patients, there were changes in the level of consciousness and the average score on the GCS was 7 (3-15).

The initial radiographic standard projections were comprised of conventional X-rays of the cervical spine in two views. In no case could the fracture be detected by analyzing these images. In 2 patients, there was a prevertebral soft-tissue shadow present

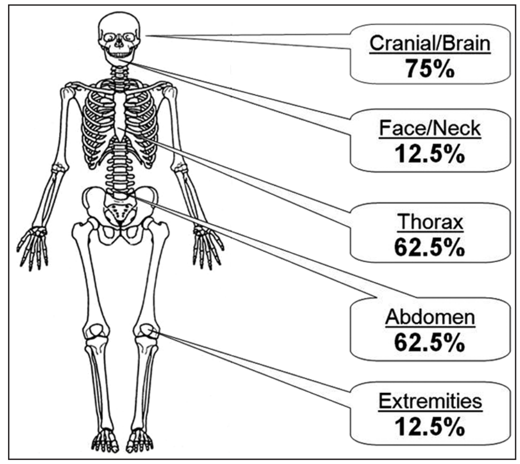

Figure 1: Associated injuries with abbreviated injury scale and #61

as an indication of injury. One of these patients had additional fractures of the 4th through the 6th cervical vertebrae. The extent of the fracture could only be determined or recognized from CT of the craniocervical junction. Dynamic examinations were avoided.

Until 2006, all patients with neurological deficits were treated from the time of admission using the cortisone protocol in accordance with NASCII 2 recommendations.

One patient died of multi-organ failure on the 18th day following the accident. In this patient, severe intracerebral injuries predominated. Among the seven remaining patients, four were immobilized for a total of 6-8 weeks using a halo fixation device. The indication for immobilization using a halo fixation device was the presence of Type III injuries on the Anderson scale or Type IIa injuries on the Tuli scale [Tables 1 and 2]. The patients with Type I injuries on the Tuli scale wore a Philadelphia cervical collar for 6 weeks. In all surviving patients, we were able to obtain current findings or interview results. The follow-up examination took place an average of 39 (10-118) months after the accident.

In one patient with symptoms of total quadriplegia, these had resolved completely (Frankel Grade A to E). In two additional patients with partial quadriplegia, their symptoms had improved from Frankel Grade B to E [Table 4].

On the first clinical follow-up six patients rated their treatment outcome as very good and one as good. Three patients were completely free of symptoms at rest, four patients reported slight pain on rapid head movement. No cranial nerve irritations or deficits were observed and specifically none involving the hypoglossal nerve. The analysis of mobility showed nearly normal values. The average score on the Hannover Spinal Trauma Scale for all of the patients was 91 (72-100) [Table 3]. On follow-up examination, CT of the craniocervical junction showed that all the healed fractures were completely remodeled with bone. In the dynamic examination under the image converter, the craniocervical junction appeared stable. At the time of the telephone interview the average score on the Hannover Spinal Trauma scale decreased to 76.6 (33-100).

Table 3: Patients demographics

Patient no. Sex	Age (years)	GCS	ISS	Additional injuries	Type Anderson *et al.*	Type Tuli *et al.*	Therapy	Follow-up (years)	HWS
1/M	17	3	75	Head trauma with brain stem and subarachnoidal bleeding with tetraparesis, hematopneumothorax and bilateral lung contusion, ruptur of the diaphragm, ruptures of splen and liver	III	IIa	Halo	11.9	100
2/M	23	3	41	Head trauma with contusion frontal left and subarachnoidal bleeding hematopneumothorax and bilateral lung contusion, ruptur of the diaphragm, ruptures of splen and bladder, pelvic fracture (acetabular and ileum fracture) With lesion of the lumbar plexus, open tibial fracture left side	III	IIa	Halo	10.3	33
3/M	18	15	34	Rupture of the liver (segments 4a, 5,6,7 and 8 with ruptures ranging to the vena cava, hematopneumothorax, head trauma with small frontal bilateral contusions and subarachnoidal bleeding	III	IIa	Halo	11.7	97
4/M	24	15	24	Burst fracture 5th cervical vertebra with subluxation of the facetts and contusio spinalis with incomplete tetraplegia, sagittal split fracture 6th cervical vertebra, fractures of the ribs 5.0+6.0 left, clavicular and scapula fractures left side	I	I	PC	19.3	100
5/M	16	5	59	Blunt abdominal trauma with ruptur of the pancreas, discoligamentous instability of the thoracic segment T4/5 with complete paraplegia, sternal fracture, hematopneumothorax with flail chest and bilateral lung contusion, transscaphoidal luxation of the Os lunatum	I	I	PC	14.8	59
6/M	29	9	26	Incomplete tetraplegia C0, subarachnoidal bleeding in the basal AB der basalen cistern, small contusion with bleeding of the spinal cord high occiipital	III	IIa	PC/†	†	
7/M	45	3	34	Head trauma with major bleeding, fractures of the thoracic vertebra 5.0-8.0, hematopneumothorax with flail chest	I	I	WHK	8.3	94
8/M	22	5	24	Haematoma of the liver, intracerebral bleeding corpus calossum und mehrere multiple small bleedings into the medullary layer, dislocatet fracture of the Os ileum (type duvernay)	Left: III Right: I	Left: IIa Right: I	Halo	5.9	53
Mean	24.3	7.3	39.6					11.7	76.6
Median	22.5	5.0	34.0					11.7	94.0
SD	9.4	5.2	18.4					4.36	27.6

Patients, sex, age, GCS=Glasgow coma scale; ISS=Injury severity score; additional injuries; classification of the occipital condyle fractures according to Anderson ***et al.*** and Tuli ***et al.***; therapy; PC=Philadelphia collar; Halo=Halo-fixateur; HWS=Grading of the outcome by the patients according to the hannover spine score

ILLUSTRATIVE CASE HISTORY

This 17-year-old patient was involved in an automobile accident as a restrained front-seat passenger. Following a head-on collision of the automobile with a truck, the drivers of both the automobile and the truck were killed. The patient was trapped in the car and at the time the emergency physician arrived, he was deeply unconscious (GCS = 3). Due to only gasping respiration, he was immediately intubated at the crash scene. At the time of admission, the patient's cardiovascular condition was unstable.

DIAGNOSES (ISS 75)

- Fracture of the left occipital condyle, Anderson and Montesano Type III; Tuli Type IIa [Figure 2].
- Brainstem hemorrhage and subarachnoid hemorrhage
- Flaccid tetraparesis
- Hemopneumothorax + bilateral lung contusion
- Ruptured diagragm
- Ruptured spleen
- Ruptured liver.

Table 4: Quadriplegic syndrome according to Frankel and course until follow-up examination. One patient with Frankel Type B died from severe head injury

Level	Characteristics	Accident	Follow-up examination
A	Complete. Neither motor nor sensory function preserved	1	
B	Incomplete. Sensory, but no motor function preserved	2	
C	Incomplete. Motor function preserved below the neurological level. Muscle strength <3/5		
D	Incomplete. Motor function preserved below the neurological level. Muscle strength ≥3/5		
E	Normal. Sensory and motor function normal	5	7

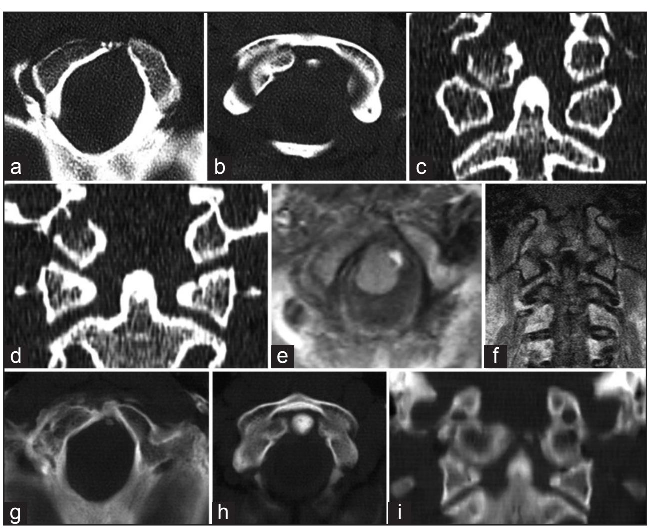

Figure 2: Fracture of the right occipital condyle; Anderson & Montesano III; Tuli 2A. a-d): Computed tomography after trauma: Condylus occipitalis fracture on the right side with typical medio-caudal dislocation of the fragment. e-f): The MRI shows neither a spinal hemorrhage nor an oedema of the spinal cord. The dislocated fragment is also clearly visible. g-i): Computed tomography 30 months after the accident: The fragment of the occipital condyle is consolidated in the dislocated position.

After initial diagnostic evaluation, immediate laparotomy took place with suturing of the diaphragm, splenectomy and repair of the ruptured liver. On conventional X-ray images, the fracture was not diagnosed. The cervical spine was initially immobilized using a Stifneck cervical collar. This was later replaced with a halo fixation device. Due to the pulmonary injuries, he received kinetic therapy in a rotational bed. The weaning phase was prolonged. The patient was initially tetraplegic without any morphological correlate having been found on CT or magnetic resonance imaging. At the time of his transfer to a rehabilitation facility on the 35th day, communication was only possible using eye movements. At this time, the patient was breathing spontaneously through a tracheal cannula. He had limited spontaneous movement in his upper extremities. The follow-up CT showed brain atrophy with enlargement of the ventricles, which was attributed to initial cerebral ischemia. The halo fixation device was left in place for 6 weeks. No additional immobilization was undertaken.

The follow-up examination of the patient took place 30 months after the accident. His neurological symptoms had completely resolved. At the time of his accident, the patient was in training to become an automotive mechanic. Because of his severe disability rating of 50%, he was re-training in a business program. From the perspective of his cervical spine, the patient was asymptomatic.

DISCUSSION

Fractures of the occipital condyle are considered to be rare injuries in the international literature. The great majority of publications about clinical cases are case reports. In the literature, there are increasing numbers of reports that include larger numbers of cases.[4-7,11-14] The largest two series of patients describe 107 factures in 95 patients and 106 fractures in 100 patients.[6,7] Among these publications with larger case numbers, five derive from radiology departments and describe the diagnostic difficulties in recognizing these fractures. The incidence in severely injured patients is reported at 1-2%.[4,6,13] The incidence in our cohort of patients with multiple trauma over a period of 14 years was 1.1% (8 out of 700 patients with multiple trauma). The incidence is greater in patients with head trauma. In a prospective series over a period of 12 months, Bloom *et al.*[5] found concomitant fractures of the occipital condyle in 9 (16.4%) of 55 patients with severe head trauma. In the study of Maserati *et al.*[7] 56 out of 100 patients with occipital condyle fracture had a traumatic brain injury. The increased numbers of cases reported is the result of improved imaging and more consistent CT imaging in severely injured patients as well as improved pre-hospital care for patients at the accident site. The cause of the injury is almost exclusively trauma from high-speed traffic accidents.[7,11,13] In our series, the mechanism of injury in 7 cases was a traffic accident. One additional patient was struck by a falling tree while working as an arborist. Young age and male gender may be regarded as risk factors for this injury in our patient series. The average age of the patients in larger series is similarly low. In the 76 patients reported by Aulino *et al.*,[11] their average age was 30 years, in the patient collective of Maserati *et al.*[7] the age average was 44 years.

In evaluating our patients for the severity and the nature of their concomitant injuries, we likewise found certain typical features. The average ISS was 37 (24-57) [Figure 1]. Severe concomitant injuries were noted in all patients. The finding of severe associated injuries corresponds to what has been reported in the literature. However, only the study of Mueller *et al.*[4] did score the severity of these injuries with ISS (average was 25.8). In a study by Aulino *et al.*[11] found concomitant chest or abdominal injuries in 50 of their 76 patients. In addition, 16 of the 76 patients had pelvic injuries and 17 of the 76 patients had associated injuries in the area of the cervical spine.

In 75% of our patients, severe intracranial injuries were also present. The average score on the GCS was 7.3 (3-15). Five patients were initially unconscious. Two patients had high-level incomplete tetraplegia and one patient was diagnosed with total tetraplegia at the T3 level. Only one patient had a normal neurological examination.

The concomitant presence of severe head injury is likewise well supported by the literature; the average score on the GCS was 10 in the series reported by Aulino *et al.*,[11] Maserati *et al.*[7] report about a GCS under 13 in 40% of the cases. Our patient cohort showed a lower average GCS score, but with the small number of patients, statistical comparisons between the individual patient cohorts are not meaningful.

Impacted fractures of the occipital condyles are considered to be stable fractures and are attributable to axial compression (the Jefferson mechanism). Skull fractures that extend to the area of the condyles are also considered to be stable.[9] Avulsion fractures (Tuli Type IIb)[10] are an indicator of instability at the craniocervical junction, since traumatic dislocation of the apex of the dens axis leads to tears of the osseous attachment of the alar ligament. Bilateral injuries likewise must be regarded as unstable.

Following Anderson and Montesano's classification, we treated five Type III and four Type I injuries. In the literature Type III fractures were diagnosed in 30-75%.[6,7,13] Following Tuli's classification, five of our patients could be regarded as Type IIa and four as Type I. The indication for immobilization using a halo fixation device was set at Type III injuries according to Anderson and Montesano and Type IIa injuries according to Tuli. The patients with a Tuli Type I injury wore a Philadelphia cervical collar for 6 weeks. Treatment of this injury is necessary, since delayed neurological deficits may result from a delay in setting indications.[15-17] For unstable injuries, we recommend surgical treatment. There is general agreement that all such treatment recommendations are based on a low level of evidence.[6,7,10,18]

Fractures of the occipital condyle require consistent imaging by CT of the craniocervical junction. In severely injured patients or patients with severe head trauma, particular attention must be paid to this area of the spine. The X-ray of the cervical spine in two views cannot be considered adequate to rule out the presence of this injury. These observations emphasize the need for consistent initial radiological diagnostic assessment.[19] For some years by now, conventional X-ray imaging has been abandoned for severely wounded patients in favor of CT.

On average, follow-up examination of our patients took place 11.7 (5.9-19.3) years after the accident. Long-term outcomes over the course of many years have not been described some report of midterm results, however, most of them had a big loss of follow-up.[13] The subjective assessment of treatment outcome was very good or good on the part of all the patients. The average score on the Hannover Spinal Trauma Scale, a subjective assessment score of treatment results that ranges from 0 to 100 points, was high with a mean value of 91 (72-100) [Table 3]. Notably this score decreased to a mean of 76.6 (33-100) at the time of the telephone interview. One patient with paraplegia that was not satisfied with the overall outcome rated his subjective assessment with 33 instead 72 at the first clinical follow-up. No correlation could be demonstrated between the severity of injury or fracture type and final outcome. The follow-up examination findings on our patients validate our treatment concept. Even in the presence of neurological deficits, we were able to achieve good subjective and functional outcomes.

The major limitation of the study is the retrospective design and great variation of the times of clinical or telephone interviews.

CONCLUSIONS

Fractures of the occipital condyles require consistent imaging by CT of the craniocervical junction. In severely injured patients or patients with severe head trauma, special attention must be paid to this area of the spine. The conventional X-ray of the cervical spine in two views is insufficient to rule out this injury. We recommend timely immobilization of the cervical spine by means of a halo fixation device for patients with Type III injuries according to Anderson or Type IIa injuries according to Tuli. This treatment manifests good to very good outcome in those patients who survive. Even patients with a complete tetraparesis syndrome can have complete resolution of their symptoms.

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