Occipital condyle fractures. Prospective follow-up of 31 cases within 5 years at a level 1 trauma centre

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Abstract

Purpose Prospective investigation of incidence and outcome of occipital condyle fractures (OCF) in a level 1 trauma centre.

Methods Over a period of 5 years, we prospectively recorded all cases of OCF, and performed a 1-year post-injury radiological and clinical follow-up using CT imaging, SF-36 and Neck Disability Index, respectively.

Results A total of 31 patients with OCF were identified. Based on a total of 2,616 CT scans that had been performed during this period, the incidence was 1.19%. There were 27 unilateral and 4 bilateral OCFs. Furthermore, 3 out of 31 patients (9.7%) were additionally diagnosed with atlanto-occipital dislocation (AOD), one of which was dorsally stabilised in a surgical procedure. All other patients were treated conservatively. 5 out of 31 patients (16.1%) died due to the severity of associated injuries. 22 out of 31 patients (70.9%) were prospectively followed-up for 1 year after trauma. During this period, CT imaging showed bony consolidation of fractures in all cases except for one, with no evidence of secondary dislocation or nonunion. Evaluation of the Neck Disability Index showed moderate disability. The SF-36 questionnaire showed an impaired quality of life in all areas; however, these were determined by associated injuries and independent of the type of fracture.

Conclusions Both unilateral and bilateral OCFs represent a stable injury regardless of the type of fracture. If AOD has been diagnosed in addition, it requires surgical

stabilisation—independent of the OCF—and it is a significant predictor for poor outcomes. The patients quality of life 1 year after trauma has not been affected by the OCF, but by the overall pattern of the injury and by comorbidities. Based on our results, we introduce a new, simple and practical classification for OCFs.

Keywords Occipital condyle fracture · Outcome · Trauma

Introduction

Occipital condyle fractures (OCFs) are rare injuries [1–4]. So far, detection rates of trauma patients in centres of the highest care level (level 1 trauma centres) have been mainly based on estimates depending on the inclusion criteria [3]. Furthermore, injuries are principally not visible in conventional cervical spine X-ray and require confirmation using computed tomography (CT) [2]. This explains why only 20 cases of OCF had been documented until 1988 [5], while as many as 116 cases were described in the literature between 1978 and 2002 when CT imaging became widely established for diagnostics [1]. Even the most common classification of OCFs by Anderson and Montesano [5] has been based solely on 6 retrospective patients, with a further modified classification based on only 3 own retrospective cases [6]. The small amount of cases explain the variety of different treatment recommendations and the lack of evidence, ranging from conservative therapy with neck support to Halo fixator to cranio-cervical fusion [1, 5, 6]. Therefore, we conducted a prospective study, for which we included all cases of OCF in our hospital between 01/01/2005 and 12/31/2009, and performed a 1-year post-injury radiological and clinical

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follow-up. In this report, we would like to take the opportunity to describe our experiences with OCFs after 5 years of prospective research.

Materials and methods

In our level one trauma centre, a total of 2,616 CT scans were made that included the occipital condyle region (cranial and/or cervical CT, including multiple trauma CT) during a prospective study between 01/01/2005 and 12/31/2009 (cut-off date). The indication in all of these cases was the detection or exclusion of a cerebral and/or cervical injury following trauma. In all cases, the scans were performed in layers of at least 2 mm between C0 and C2 including axial, sagittal, and coronal reconstruction of the condyle region (Siemens, Somatom Sensation 16, Germany). All CT scans were documented prospectively. If an OCF was detected (interdisciplinary by radiology and trauma surgery), the following empirical data and the further clinical course of the patients, including injury patterns, were recorded as part of a dissertation in an additional database (SPSS): sex, age, lateral localisation, cause of accident, initial Glasgow Coma Scale (GCS) rating, and Injury Severity Score (ISS). Fracture types were classified according to Anderson and Montesano [5]: type 1 includes compression fractures without or with slight dislocation of the fragment; type 2 includes skull base fractures with additional fracture lines ending in the foramen magnum; and type 3 includes avulsion fractures with avulsion of the alar ligaments.

Independent of the three types of fractures, all patients received a hard cervical collar (type ASPEN, from Biomet GmbH, Berlin, Germany) for 6 weeks. If atlanto-occipital dislocation (AOD) had been diagnosed by means of CT imaging, the indication for dorsal cranio-cervical stabilisation using a screw-rod system was met.

Twelve months after trauma, the lead author and another co-author performed a prospective follow-up, for which patients were contacted by telephone or in writing for an outpatient visit. A clinical follow-up using the SF-36 [7], and the Neck Disability Index [8] (which had been translated into German language) was performed. Another CT scan of the condyle region (C0–C2) in 2 mm layers and reconstructions was made on this occasion and compared with the recordings at the time of the trauma.

Statistical analysis

The SPSS statistic software for Windows (version 17.0) was used for the statistical analysis. Descriptive statistics were used to determine median values, standard deviations

(SD) and ranges. The non-parametric Mann–Whitney U test and the Chi-Quadrat test were used for significance testing. p values of ≤ 0.05 were considered significant.

Results

A total of 31 patients and 35 OCFs, respectively, were diagnosed, of which 27 patients had unilateral and 4 had bilateral OCFs. The left condyle was fractured in 16 cases, the right condyle in 19 cases. The gender distribution showed 20 male and 11 female patients, and median age was 37 years (range 15–88 years).

A minimum of 5 and a maximum of 8 patients with OCF were recorded each study year. Thus, the overall incidence was 1.19%, based on a total of 2,616 CT scans that were performed.

The cause of the injury in 21 out of 31 cases (67.7%) was a high speed trauma due to traffic accident (14 by car, 5 by motorcycle, 1 by train, and 1 by boat). Other injuries resulted from falls of at least 2 m (3 patients) or from falling down the stairs (2 patients). In 4 other cases, patients had fallen off a bicycle or a wheelchair, or suffered direct head injury by a large animal and by a falling low-loader ramp, respectively. One patient slipped and fell on an icy surface without any external cause.

13 out of 31 patients (41.9%) had been primarily intubated at the site of the accident, and the average initial GCS for all patients was 11.8 points. There was no case of isolated OCFs; all patients showed additional, sometimes severe brain injury, and the average ISS was 25.8 points. Imaging did not show any injuries of the vertebral artery, and neurological findings showed initial trochlear nerve paresis in only 2 patients. Paresis of the hypoglossal nerve was not diagnosed in any patient.

12 months after trauma, 22 out of 31 patients (70.9%) were prospectively followed-up clinically and by imaging (5 patients died, 4 patients refused follow-up, of which 2 had quadriplegia). Only 1 patient (OCF with AOD) out of 3 patients with quadriplegia agreed to follow-up. All condyle fractures, with one exception (fragment dislocation 4 mm), showed bony consolidation, and no secondary displacement was found. Furthermore, no signs of arthrosis were detected at that time. Clinical evaluation of the Neck Disability Index [8] showed a median rating of 10.5 points ($SD \pm 8.3$), corresponding to disability of 21% ($SD \pm 16.6\%$) and moderate limitation, respectively. On a visual analogue scale for neck pain with a minimum of 0 and a maximum of 8, the median was 3 (range 0–8, $SD \pm 2.9$). The SF-36 questionnaire [7] showed that the quality of life 1 year after trauma was significantly reduced in all areas, which however was due to the overall pattern of injury and not due to the occipital condyle fracture.

According to the classification of Anderson and Montesano [5], there were 27 cases of unilateral OCFs and 4 cases of bilateral OCFs divided into a total of 23 type 1 (Fig. 1a, b), 5 type 2, and 7 type 3 (Fig. 2 a, b) injuries. Mortality in patients with unilateral OCF without AOD was 8.3% (Table 1): statistical analysis showed no significant differences across the three types of fractures with regard to initial ISS, mortality, or functional outcome, when the same conservative treatment regimen had been used.

Overall mortality was 16.1% (Table 1): 5 out of 31 patients died as a result of the associated intracerebral injuries after a median period of 4 days after trauma (range 0–19); no patient died as a result of the OCF. The median ISS for these 5 patients was significantly higher than that of the 26 surviving patients (50 vs. 17 points; $p < 0.001$).

The mortality rate in those 4 patients with bilateral OCFs (Fig. 3a, b)—all of them without any evidence of AOD—was 25% (1 patient): 2 out of 4 patients with bilateral OCFs survived with spastic quadriplegia due to severe TBI. Follow-up was rejected by both patients. Bilateral OCFs without AOD, compared to unilateral OCFs, showed a significantly higher initial ISS (33 vs. 17

Fig. 1 **a** Coronal CT image: OCF type 1 according to Anderson/Montesano [5], left side. **b** Coronal CT image: OCF type 1, left side, 1 year post-injury

Fig. 2 **a** Axial CT image: OCF type 3, according to Anderson/Montesano [5], left side. **b** Axial CT image: OCF type 3, left side, 1 year post-injury

points, $p = 0.039$), a higher mortality, and a worse clinical outcome caused by trauma impact.

3 out of 31 patients (9.7%) were shown to have an additional AOD. The mortality rate (2 out of 3 patients) in this patient group was 66.7% (Table 1). In all cases, initial CT imaging showed sagittal translation displacement and/or a distraction between C0 and C1 of >1–2 mm. In one case, cranio-cervical dorsal instrumentation (Fig. 4a, b, c) was performed immediately on the day of admission. One year after surgery, this patient had spastic quadriplegia due to this subaxial injury; still the patient himself is mobile in his wheelchair. The other two patients who had a poor prognosis received a cervical neck support, and both died (independently of the OCF) within a few days due to their severe brain injuries.

Table 1 Mortality rate in patients with confirmed OCFs

Diagnosis	No. of patients	Percentage (%)
OCFs total	5/31	16.1
Unilateral OCF without AOD	2/24	8.3
Bilateral OCF without AOD	1/4	25.0
OCF with AOD	2/3	66.7

Fig. 3 **a** Coronal CT image: bilateral OCF. **b** Coronal CT image: bilateral OCF, 1 year post-injury

Discussion

OCFs are rare [1, 3, 9], and thus almost all available data are retrospective [1, 3, 9], sometimes based on a small number of cases, and some of the studies with larger number of cases are characterised by incomplete follow-up and a high loss to follow-up [3, 4]. This study has been the first to prospectively collect OCF data in a level 1 trauma centre over a period of 5 years to summarise a larger number of cases. Incidence of this injury was 1.19%, while other studies have only provided estimates so far,

Fig. 4 **a** Coronal CT image: OCF type 3, according to Anderson/Montesano [5], *left side*, AOD *right side*. **b** Sagittal CT image: OCF type 3, *left side*, **c** Sagittal CT image: OCF type 3, *left side*, 1 year post-injury after cranio-cervical instrumentation

depending on the inclusion criteria, with a significantly lower incidence [2, 4]. Our data indicate that at least 1 out of 100 patients should be expected to have OCFs, if

diagnostic CT scans are made after relevant injuries. Tuli et al. [6] reported an approximately equal incidence (1 out of 93 patients), but these data were collected retrospectively with a smaller number of cases. It must be stressed again that it is principally not possible to detect OCFs with conventional X-ray imaging [6, 9]. If subaxial injuries are suspected in children, MRI can be taken into account for OCF detection, in order to prevent exposure to radiation [10]. In our study, however, no OCF was primarily diagnosed using MRI.

The major cause for OCF is high speed trauma often associated with serious injuries, severe traumatic brain injury in particular; this has also been confirmed by other studies [2, 4]. On the other hand, however, a simple fall does not exclude such injuries, as our data has shown. Overall, a mortality rate of 16.1% was shown, though this rate drops to 8.3% (8 out of 24 patients) for cases with unilateral OCFs without evidence of AOD. These results, therefore, fall within the range of other study data [2, 4].

Anderson and Montesano [5] distinguished among three types of fractures: type 1 was described as a compression fracture of the condyle, without significant displacement into the foramen magnum. Type 2 was described as a basilar skull fracture with extension into the occipital condyle, without displacement into the foramen magnum. Both types are found to be a stable entity. Type 3 was characterised as an avulsion fracture of the occipital condyle secondary to stress on the ipsilateral alar ligament. This 3-type classification has only been based on 6 retrospective cases. Yet, it has not been modified since then and it is still being used as a classification and reference in current studies [2]. On the other hand, it was suggested in other studies that this classification might prove difficult to use, because an accurate diagnosis that differentiates type 1, 2, or 3 injuries is not always possible in a reliable manner [2, 4]. This has also been reflected by the variety of observed frequency rates: Malham et al. [3] and Maserati et al. [4] diagnosed less than 30% type 3 injuries in their studies, while Hansen et al. [2] found 75%. In our study, by contrast, the frequency of this type of fracture was as low as 20%. We can confirm such classification difficulties. Even our classification may have a low inter- and intra-observer reliability particularly with respect to type 1 and type 3 injuries. However, the validity of classifications was not the subject of the study. On the other hand, our statistical analysis did not show any significant differences among these 3 types of fractures—with regard to trauma severity (ISS), radiological and clinical outcome (SF-36), and mortality—when patients received the same conservative treatment with immobilisation using a cervical collar (hard or rigid collar) for 6 weeks. In our opinion, therefore, this classification is negligible and without clinical consequence.

Similarly, our results show that the application of the Halo fixator is not necessary in patients with unilateral OCFs without AOD, as it has been partially postulated in other studies [3]. In our opinion, the 6-week application of a cervical collar is sufficient, and we have found radiological healing without secondary dislocation in our follow-up of this treatment. Another author [1] recommends the duration of this treatment of up to 3 months in patients with stable injuries. It must be pointed out that the application of a Halo fixator in ventilated and/or multiple trauma patients is complex, and a variety of difficulties and complications may occur.

Our recommendation for a conservative treatment with cervical collar also applies to the rare cases of bilateral OCFs without AOD, though particularly in fatal injury patterns mainly bilateral condyle fractures are present [11]. In such cases, much higher kinetic forces with serious injury patterns must be expected, leading to high ISS scores. Similarly, we found significantly higher morbidity and mortality rates for bilateral OCFs as opposed to unilateral OCFs without AOD in our patient population. On the other hand, there was no secondary displacement with conservative treatment. Thus, even this fracture may be considered stable (while taking into account the small number of cases in our study). Other authors [4, 12] also consider immobilisation of bilateral OCFs to be sufficient using conservative measures such as a cervical collar. They did neither report any evidence of secondary dislocation nor instability. The modified classification of Tuli et al. [6] does not address the significance of unilateral or bilateral OCFs. Its treatment algorithm is based on the distinction between dislocated and non-dislocated injuries and on the C1/C2 segment in particular. Therefore, it cannot be directly applied to the condyle region. And even in that study, the author only presented 3 retrospective cases [6].

In our study, OCFs with additional AOD were diagnosed in 3 out of 31 patients (9.7%). Compared to unilateral or bilateral OCFs without AOD, mortality rates are significantly increased in patients with this extremely rare subaxial combination injury, and it was 67% in our study with a small number of cases. If the general situation of the multiple trauma patient allows to do so, surgical dorsal cranio-cervical stabilisation is principally required for confirmed AOD due to the high instability [4]. Similarly, we were unable to perform this operation in 2 out of 3 cases due to poor prognosis and unstable circulatory conditions; both patients died of their severe brain injury. Clinically, the results of the SF-36 questionnaire and the Neck Disability Index were negatively influenced by the associated injuries; the unilateral fracture types according to Anderson and Montesano [5] showed no significant differences in outcome. It should be noted that no valid German translation of the Neck Disability Index [8] has been available

Table 2 OCF classification

Occipital condyle fracture	Classification	Treatment/reasoning
Unilateral OCF without AOD (Type 1, 2, 3 due to Anderson/Montesano)	Type 1, stable	Conservative, 6 week neck tie lowest mortality rate, best outcome
Bilateral OCF without AOD	Type 2, stable	Conservative, higher comorbidity and mortality, significant
Unilateral or bilateral OCF with AOD	Type 3, unstable	Surgical, dorsal stabilisation, highest morbidity, highest mortality, significant

so far; thus, interpretation of the results is limited. The mobility of the cervical spine has been deliberately not verified in our study, because the occipito-atlanto joint allows no significant rotation and only limited extension and flexion due to the configuration of the ligament structures [13]. After 5 years of prospective research, we present a new, simple and practical classification, which accounts for the therapy and outcome of occipital condyle fractures (Table 2), based on the results and analyses of our study. This classification does not take into account displaced OCFs, which may cause brain stem constriction due to direct fragment dislocation in the spinal canal, and may require immediate direct surgical decompression and stabilisation. So far, only anecdotal reports and a wide range of different treatment options for this entity have been described in the literature, ranging from conservative treatment with immobilisation only [14] to the recommendation of surgical decompression and stabilisation [1, 6]. In our study of more than 5 years, we have seen no such case.

Conclusions

In a centre of the highest care level, at least 1 out of 100 patients should be expected to have an OCF, if diagnostic CT imaging is indicated. Both unilateral and bilateral OCFs represent a stable injury regardless of the type of fracture, and both types can be treated by immobilisation using a cervical collar. If AOD has been diagnosed in addition, it principally requires surgical stabilisation—independent of the OCF—and it is a significant predictor for poor outcomes. The patients quality of life has not been affected by the OCF, but by the overall pattern of injury and by comorbidities. Based on our results, we introduce a new simple and practical classification for OCF.

Conflict of interest None.

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