Reliability of the Oswestry-Bristol Classification for trochlear dysplasia
EXPANDED CHARACTERISTICS

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Aims
The Oswestry-Bristol Classification (OBC) was recently described as an MRI-based classification tool for the femoral trochlea. The authors demonstrated better inter- and intraobserver agreement compared to the Dejour classification. As the OBC could potentially provide a very useful MRI-based grading system for trochlear dysplasia, it was the aim to determine the inter- and intraobserver reliability of the classification system from the perspective of the non-founder.

Methods
Two orthopaedic surgeons independently assessed 50 MRI scans for trochlear dysplasia and classified each according to the OBC. Both observers repeated the assessments after six weeks. The inter- and intraobserver agreement was determined using Cohen’s kappa statistic and S-statistic nominal and linear weights.

Results
The OBC with grading into four different trochlear forms showed excellent inter- and intraobserver agreement with a mean kappa of 0.78.

Conclusion
The OBC is a simple MRI-based classification system with high inter- and intraobserver reliability. It could present a useful tool for grading the severity of trochlear dysplasia in daily practice.

Cite this article: Bone Joint Open 2020;1-7:355–358.

Keywords: knee, anterior knee pain, patella instability, trochleoplasty, patellofemoral joint, MPFL, patella dislocation

Introduction
In patients with patellofemoral instability, dysplasia of the femoral trochlea is common, as trochlear dysplasia is the most important risk factor for recurrent patella dislocation.1-4 Therefore, besides analyzing all other passive and active stabilizers of the patellofemoral joint, it is important to assess the form of the femoral trochlea during the individual workup of the pathomorphological causes of patella instability.

For grading of trochlear dysplasia, Dejour et al3 introduced a three-grade classification system in 1990. It was subsequently modified in 1998 to four grades in order to improve the inter- and intraobserver agreement.6,7 Still, the Dejour classification system, which was based on radiographs and CT, demonstrated an inconsistent inter- and intraobserver agreement throughout the literature over the years, especially when MRI was used.8-13

In 2020, Sharma et al14 published a new classification system for trochlear dysplasia: the Oswestry-Bristol Classification (OBC). This MRI-based, four-grade system is depicted in figure 1.

The OBC could potentially provide a very useful grading system for trochlear dysplasia. It was the purpose of this study to firstly validate the inter- and intraobserver agreement of the classification system by non-founding authors.

Methods
From our database, we retrospectively identified 50 knee MRI scans, which were performed.
in different patients who presented due to patellofemoral symptoms of pain or instability. These patients did not have any history of knee surgery altering the form of the femoral trochlea prior to MRI.

Two orthopaedic surgeons (Orthopaedic Sports Medicine Fellow (SSA)/Fellowship-trained Senior Consultant (CK)) independently graded the axial T2-weighted MRI slices according to OBC, in normal trochlea, mild trochlear dysplasia (shallow trochlea), moderate (flat trochlea), or severe (convex trochlea) trochlear dysplasia. Both observers repeated the assessments after six weeks. For the second phase, the order of MRI scans was randomized to eliminate any bias from the first reading.

We determined the interobserver agreement using Cohen’s kappa statistic. A kappa value greater than 0.75 represents excellent agreement beyond chance, whereas values below 0.40 represent poor agreement. We also determined the S-statistic to verify the kappa value.

For determining the intraobserver agreement, we calculated the mean kappa of both observers. All statistical analyses were performed using the software R, Vienna, Austria.
The agreement was 90% and in the second round it was 96%. Also, the intraobserver agreement was excellent with a kappa-value of 77% for the first observer and a kappa-value of 79% for the second observer.

### Results

According to the ratings of both orthopaedic surgeons using the OBC, 6% (n = 3) of all trochleae were classified as normal, 56% (n = 28) as mild dysplastic, 22% (n = 11) as moderate dysplastic, and 16% (n = 8) as severe dysplastic.

We determined the interobserver agreement, kappa-statistic and S-statistic values separately for each set of observations (Table I). In the first round of observations, the agreement was 90% and in the second round it was 96%. Also, the intraobserver agreement was excellent with a kappa-value of 77% for the first observer and a kappa-value of 79% for the second observer.

### Discussion

This study represents the first inter- and intraobserver agreement validation of the MRI based OBC for trochlear dysplasia by non-founders. We demonstrated excellent intra- and interobserver reliability of the classification tool.

In specialized orthopaedic departments, patients with patellofemoral instability symptoms present regularly. Besides history and thorough clinical examination, radiograph examination and MRI of the knee represent part of the standard workup.

The originally CT-based Dejour Classification for trochlear dysplasia is known to be the standard grading system for the form of the trochlea. This classification system showed inconsistent intra- and interobserver reliability in several studies, whereas the first classification of Henri Dejour, published in 1990 (three grades), demonstrated lower agreements than the second classification by David Dejour, published in 1998 (four grades). An advantage of the OBC over the Dejour classification besides its simplicity is that it can reliably be used with standard T2-weighted axial MRI slides of the knee. Furthermore, it simplifies the classification to relevant categories.

In Table II, we summarize the OBC and add aspects, which we consider as important. This overview should facilitate future usage of the classification system as much as possible.

We find differentiation between normal (Type 0) and shallow (Type 1) trochlea the single most difficult aspect in the application of the OBC. Potentially, the sulcus angle might be helpful to differentiate between a normal form of the trochlea and a mild trochlear dysplasia. But the normal sulcus angle differs widely in healthy knees. The so-called “Oblique Trochlear View (OTV)” means special and modified axial MRI slides of the knee for evaluation of the femoral trochlea. The OTV displays a more uniform sulcus angle and depth along the trochlea. But this requires a modified MRI or software, which is not available on regular daily basis as patients normally present with a standard MRI of their symptomatic knee. Additionally, there are gender-related differences in the sulcus angle: females have a significantly greater sulcus angle than males. Thus, the sulcus angle is not a perfect differentiator between a normal (Type 0) and shallow (Type 1) trochlea, although a recently published review and meta-analysis found a cartilaginous sulcus angle of at least 143° in patients with patellofemoral instability. Nevertheless, deciding if a certain individual trochlear form is normal (Type 0) or mildly dysplastic (Type 1) remains partially subjective. Differentiation between greater degrees of trochlea dysplasia according to the OBC seems to be more reproducible.

Carrillon et al described the Lateral Trochlear Inclination (LTI). This is an angle measured on axial MRI between the posterior condylar line and the lateral trochlear facet. The authors demonstrated an LTI of 11° or higher in stable patellofemoral joints and an LTI < 11° in patellofemoral instability.

As there are many aspects involved in patellofemoral instability, a treatment algorithm cannot be developed from a classification for trochlear dysplasia alone. But we like to mention that patella height correlates with trochlear dysplasia: a higher positioned patella is associated with a more dysplastic trochlea. We hypothesize that a severely dysplastic trochlea is responsible for a patella alta and leads to shortening of the quadriceps muscle. This is important for planning of surgical treatment, as a distalization of the

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**Table I.** Interobserver agreement, kappa-statistic, and S-statistic values for the first and second round of observations.

| Round of assessment | Observed agreement | Expected agreement | Kappa (95% CI) | S-statistic (nominal) (95% CI) | S-statistic (linear weights) (95% CI) |
|---------------------|--------------------|--------------------|---------------|-------------------------------|----------------------------------------|
| 1                   | 90.0%              | 86.96%             | 0.69          | 1.480                         | 1.960                                  |
| 2                   | 96.0%              | 89.04%             | 0.77          | 1.645                         | 1.645                                  |

CI, confidence interval.

**Table II.** Expanded characteristics of the MRI-based Oswestry-Bristol Classification (OBC) for trochlear dysplasia.

| OBC Type | Form of trochlea | Severity of trochlear dysplasia | Cartilaginous sulcus angle | Lateral Trochlear Inclination (LTI) | Indications for trochleoplasty? |
|----------|-----------------|-------------------------------|---------------------------|-----------------------------------|--------------------------------|
| 0        | Normal          | No trochlear dysplasia Normal ( < 145°) | ≥ 11° | No                       |                                |
| 1        | Shallow         | Mild                           | < 11°                      | No                                |                                |
| 2        | Flat            | Moderate                       | 180°                      | Seldom needed                     |                                |
| 3        | Convex          | Severe                         | > 180°                    | Consider trochleoplasty           |                                |

MRI, Magnetic Resonance Imaging.
tibial tuberosity alone seems to be unsuccessful in severe
trochlear dysplasia with a convex trochlea form.

In conclusion, the Oswestry-Bristol Classification (OBC)
as an MRI based grading system for trochlear dysplasia
showed excellent intra- and interobserver agreement.
Therefore and because of its simplicity in usage, the OBC
seems to be a very good system for classifying trochlear
dysplasia in daily practice.

Take home message
- The Oswestry-Bristol Classification (OBC) is an easy to use
grading system for trochlear dysplasia with excellent inter-
and intraobserver reliability.

References
1. Dejour H, Walch G, Nove-Josserand L, Guier C. Factors of Patellar instability: an
anatomic radiographic study. Knee Surg Sports Traumatol Arthosc. 1994;2(1):19–26.
2. Farahmard F, Senavongse W, Amis AA. Quantitative study of the quadriceps
muscles and trochlear groove geometry related to instability of the patellofemoral
joint. J Orthop Res. 1998;16(1):136–143.
3. Farahmard F, Tahmasbi MN, Amis AA. Lateral force-displacement behaviour of
the human patella and its variation with knee flexion—a biomechanical study in vitro.
J Biomech. 1998;31(12):1147–1152.
4. Redziniak DE, Dierich DR, Mihalko WM, et al. Patellar instability. J Bone Joint
Surg Am. 2009;91(9):2284–2275.
5. Dejour H, Walch G, Neyret P, Adleine P. La dysplasie de la trochlée fémorale [Dysplasia
of the femoral trochlea]. Rev Trav Ortop Reparatrice Appar Mot. 1990;76(1):45–54.
6. Dejour D, Reynaud P, Lecoultre B. Douleurs et instabilité rotulienne, Essai de
classification. Med Hyg. 11998;56(2217):1466–1471.
7. Dejour D, Saggion P. The sulcus deepening trochleoplasty—the Lyon’s procedure.
Int Orthop. 2010;34(2):311–316.
8. Rémy F, Chantelot C, Fontaine C, et al. Inter- and intraobserver reproducibility in
radiographic diagnosis and classification of femoral trochlear dysplasia. Surg Radiol
Anat. 1998;20(4):265–293.
9. Lippacher S, Dejour D, Elsharkawi M, et al. Observer agreement on the Dejour
trochlear dysplasia classification: a comparison of true lateral radiographs and axial
magnetic resonance images. Am J Sports Med. 2012;40(4):837–843.
10. Nelitz M, Lippacher S, Reichel H, Dornacher D. Evaluation of trochlear dysplasia using
MRI: correlation between the classification system of Dejour and objective parameters of
trochlear dysplasia. Knee Surg Sports Traumatol Arthosc. 2014;22(1):129–127.
11. Nelitz M, Lippacher S. Arthroscopic evaluation of trochlear dysplasia as an aid
in decision making for the treatment of patellofemoral instability. Knee Surg Sports
Traumatol Arthosc. 2014;22(11):2788–2794.
12. Step'anovich M, Bomar JD, Pennock AT. Are the current classifications and
radiographic measurements for trochlear dysplasia appropriate in the skeletally
immature patient? Orthop J Sports Med. 2016;4(10).232596711666949.
13. Mousinho RSMS, Ribeiro JNA, Pedrosa FKS, et al. Evaluation of the
reproducibility of the Dejour classification for femoropatellar instability. Rev Bras
Ortop. 2010;54(2):171–177.
14. Sharma N, Brown A, Bouras T, et al. The Oswestry-Bristol classification: a new
classification system for trochlear dysplasia. Bone Joint J. 2020;102-B(1):102–107.
15. Shoukri MM. Measures of interobserver agreement and reliability. Boca Raton,
Florida, USA: CRC Press, 2004.
16. Fleiss JL, Levin B, Paik MC. Statistical methods for rates and proportions. Hoboken,
ed. Third New Jersey: John Wiley & Sons, 2003.
17. Marasini D, Quatto P, Ripamonti E. Assessing the inter-rater agreement for
ordinal data through weighted indexes. Stat Methods Med Res. 2016;25(6):2611–2633.
18. Light RJ. Measures of response agreement for qualitative data: some generalizations
and alternatives. Psychol Bull. 1971;76(5):365–377.
19. Hochreiter B, Hess S, Moser L, et al. Healthy knees have a highly variable patellofemoral
alignment: a systematic review. Knee Surg Sports Traumatol Arthosc. 2020;28(2):395–406.
20. Ambra LF, Galvão PHSAF, Mameri ES, Farr J, Gomoll AH. Femoral trochlear
geometry in patients with trochlear dysplasia using MRI oblique trochlear view. J
Knee Surg. 2019. Epub ahead of print.
21. Koh Y-G, Nam J-H, Chung H-S, et al. Gender-Related morphological differences in
sulcus angle and condylic height for the femoral trochlea using magnetic resonance
imaging. Knee Surg Sports Traumatol Arthosc. 2019;27(11):3560–3566.
22. SJS T, Chng KSJ, Lim BY, et al. The difference between cartilaginous and bony sulcus
angles for patients with or without patellofemoral instability: a systematic
review and meta-analysis. J Knee Surg. 2020. Epub ahead of print.
23. Carrillon Y, Abidi H, Dejour D, et al. Patellar instability: assessment on MR images by
measuring the lateral trochlear inclination—Initial experience. Radiology. 2000;218(2):582–595.
24. Ferlic PW, Rimer A, Dammereer D, et al. Patella Height Correlates With Trochlear
Dysplasia: A Computed Tomography Image Analysis. Arthroscopy. 2018;34(6):1921–1928.

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- C. Konrads: Planned the study. Collected and analyzed the data, Wrote the
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- S. Ahmad: Collected the data, Revised and approved the manuscript.

Funding statement:
- No benefits in any form have been received or will be received from a commercial
party related directly or indirectly to the subject of this article.

Acknowledgements
- This publication was supported by the German Research Foundation (DFG) and the
University of Tübingen in the funding programme Open Access Publishing.

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