

## Review Article

# Cemented and cementless total hip arthroplasty in patients with osteoporosis: an overview

Ilias P. Mystidis<sup>1</sup>, Dimitrios Chytas<sup>2</sup>, Maria Kyriaki Kaseta<sup>1</sup>, Dimitrios V. Papadopoulos<sup>1</sup>,  
Elisavet Mantzila<sup>1</sup>, Vasiliki Kakogeorgou<sup>1</sup>, Efstathios Chronopoulos<sup>3</sup>

<sup>1</sup>2<sup>nd</sup> Orthopedic Department of National and Kapodistrian University of Athens, Konstantopoulou-Patission General Hospital, Nea Ionia, Greece;

<sup>2</sup>Basic Sciences Laboratory, Department of Physiotherapy, University of Peloponnese, Sparta, Greece;

<sup>3</sup>KAT Hospital, Research Department of Musculoskeletal diseases, Kifisia, Greece

## Abstract

The purpose of the current review article was to explore to what extent the literature supports cemented or cementless total hip arthroplasty (THA) in osteoporotic patients., in terms of Harris Hip Score, periprosthetic bone loss, periprosthetic fractures, prosthesis subsidence and revision rate. A literature search was performed in PubMed and Cochrane databases to identify articles with purpose to investigate the aforementioned parameters after the use of cemented or cementless THA in patients with osteoporosis or Dorr type C bone, which is typically seen in those patients. Twenty studies were included in the review. Among them, there were two studies which compared cemented with cementless THA in osteoporotic patients and found better outcomes after cemented fixation. The remaining studies investigated only the outcomes of cementless THA in patients with osteoporosis or Dorr type C bone. Most of those studies showed satisfactory outcomes and suggested that cementless THA may not be contraindicated for those patients. The major issue concerning cementless THA was the relatively high rate of periprosthetic fractures. Three studies investigated the use of anti-osteoporotic medication in osteoporotic patients who underwent cementless THA and found positive outcomes. In conclusion, the role of cemented and cementless THA in the case of osteoporosis or Dorr type C bone needs to be further clarified with more comparative studies.

**Keywords:** Cemented total hip arthroplasty, Cementless total hip arthroplasty, Osteoporosis

## Introduction

Although total hip arthroplasty (THA) has been for several decades an intervention which has markedly improved the quality of life of millions of patients suffering from a wide spectrum of hip trauma and disease, there is still controversy about the possible use of cement for implant fixation. A characteristic example of a field of this controversy is the case of osteoporosis, a disease which concerns millions of patients worldwide. From a biomechanical point of view, it has been shown that, under simulated walking conditions, the failure of osteoporotic femora implanted with cementless stem designs was significantly more frequent in comparison with non-osteoporotic femora<sup>1</sup>. However, in that study<sup>1</sup>, the subsidence of cemented versus uncemented stems in osteoporotic femora was not investigated. Recently, articles which reviewed the outcomes of cemented femoral fixation in hip replacement recommended cemented THA in patients

suffering from osteoporosis or having a Dorr type C femur<sup>2,3</sup>. This type is characterized by wide, stovepipe-shaped canal and thin cortices of the proximal femur<sup>4</sup>. It has been shown that this shape of femur is histologically correlated with low bone mineral density (BMD)<sup>4</sup> and it predominantly corresponds to elderly osteoporotic patients<sup>5</sup>.

However, the aforementioned review articles did not focus on the use of cemented or cementless implants at

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**Corresponding author:** Ilias P. Mystidis, Piperopoulou 10 A,  
14575 Athens, Greece

**E-mail:** dr.mistidis@gmail.com

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Authors	Number of participants	Mean follow-up	Main outcomes
Zhen et al. <sup>9</sup>	25 patients with Dorr type C femur	125 months	The Harris Hip Score was markedly improved and the radiological control showed good osseointegration of the prostheses.
McLaughlin and Lee <sup>10</sup>	320 patients with femora of type A, B or C	16.6 years	Satisfactory fixation in all three types.
Kim et al. <sup>11</sup>	247 patients with femora of type A, B or C	13.2 years	Insignificant difference between the three types in terms of Harris Hip Score, rate of periprosthetic fractures and osteolysis.
Zhen et al. <sup>12</sup>	35 patients with Dorr type C bone	5.5 years	Improved Harris Hip Score and satisfactory osseointegration of the prostheses.
Ahmad Hatem et al. <sup>13</sup>	87 patients with femur of the 3 Dorr types (A, B and C)	2.8 years	Improved Harris hip Score for all types. No revision. Insignificant differences in clinical outcomes and osseointegration between the femurs of the 3 Dorr types.
Syed et al. <sup>14</sup>	176 patients with femur of the 3 Dorr types (A, B and C)	1 year	Dorr type had no effect on the risk of periprosthetic fracture or subsidence of the prosthesis.
Rattanaprichavej et al. <sup>15</sup>	311 patients with femur of the 3 Dorr types (A, B and C)	44.1 months	Type B and C femurs showed a statistically insignificant difference in subsidence compared with type A.

**Table 1.** Studies which focused on Dorr femur types and supported the use of cementless THA in Dorr type C femora without comparison between cemented and cementless THA.

those patients and did not compare the outcomes between those two types of fixation in the case of osteoporosis. The review by Karachalios et al.<sup>6</sup> investigated the use of THA in patients suffering from this disease, but the focus was not on the use of cemented or cementless implants. The authors considered that cemented THA is preferable, but also demonstrated that several studies showed satisfactory outcomes of uncemented implants in osteoporotic patients and generally in patients with Dorr type C femur. However, there was again lack of data to demonstrate which of those two types of fixation is preferable for those patients. The purpose of the current review article was to show to what extent the literature supports that either cemented or cementless THA is recommended for osteoporotic patients, in terms of Harris Hip Score (HHS), periprosthetic bone loss, periprosthetic fractures, prosthesis subsidence and revision rate.

## Material and Methods

A literature search was performed at the databases PubMed and Cochrane with the key words: (“hip arthroplasty” OR “hip replacement”) AND (“osteoporosis” OR “Dorr” OR “type C”) AND (“cemented” OR “cementless” OR “uncemented” OR “non-cemented”). The search was completed on March 15, 2023. The inclusion criteria were: papers with purpose to explore certain clinical or radiological outcomes (HHS, periprosthetic bone loss, periprosthetic fractures, prosthesis subsidence and revision rate) of the use of cemented or cementless THA or both, in patients with

osteoporosis or Dorr type C bone, published in peer-reviewed journals and written in the English language. To be up-to-date, only articles published in the last decade (after 2013) were eligible for inclusion. The key words “Dorr” and “type C” were used because this type of femur is typically seen in osteoporotic patients<sup>5</sup>. The exclusion criteria were: letters to the Editor, review articles, commentaries and papers without purpose to find specific clinical or radiological outcomes of the use of cemented or cementless THA in osteoporotic patients or patients with Dorr type C bone. The screening process comprised three stages: title, abstract and full text. If the title of the article was inadequate to indicate if the paper would be included or excluded, then the abstract was screened. If the abstract was again insufficient to determine if the article would be included or excluded, then the full text was screened. From each included paper, the following data were extracted: author(s), number of patients, mean follow-up, type of THA and the aforementioned outcomes of cemented or cementless THA in patients with osteoporosis or Dorr type C bone.

## Results

In total, 205 articles were retrieved after the initial search. Two reviews, one basic-science article, one article not written in English, 7 articles without focus on the aforementioned outcomes (HHS, periprosthetic bone loss, periprosthetic fractures, prosthesis subsidence and revision rate) of cemented or cementless THA in patients with osteoporosis or Dorr type C bone and 174 irrelevant

Authors	Number of participants	Mean follow-up	Main outcomes
Tsubosaka et al. <sup>16</sup>	90 patients with femur of the 3 Dorr types (A, B and C)	5 years	Relatively high stress shielding in patients with a Dorr type C femur.
Kheir et al. <sup>17</sup>	709 patients with femur of the 3 Dorr types (A, B and C)	2.7 years	Much higher periprosthetic fracture rate for Dorr Type C femur.
Gromov et al. <sup>18</sup>	1441 patients with femur of the 3 Dorr types (A, B and C)	713 days	Patients with femur Dorr type C had a much higher risk of postoperative periprosthetic fracture.
Gkagkalis et al. <sup>19</sup>	360 patients with femur of the 3 Dorr types (A, B and C)	49.2 months	In elderly patients with type C femurs there was a much higher incidence of periprosthetic fractures.

**Table 2.** Studies which focused on Dorr femur types and did not support the use of cementless THA in Dorr type C femora, without comparison between cemented and cementless THA.

articles were excluded. Thus, 20 papers were included in the review.

### **Studies which compared the outcomes between cemented and cementless THA in patients with osteoporosis**

Two papers compared the outcomes between cemented and cementless THA in osteoporotic patients<sup>7,8</sup>. More specifically, Yang et al.<sup>7</sup> studied 496 elderly patients with osteoporosis who underwent THA. In 184 of them cement was used in the femoral prosthesis, while in 182 it was not. The mean follow-up was 75 months. From 3 months postoperatively to the last examination, the Harris Hip Score (HHS) was consistently superior in patients in whom cement was used. The revision in a period shorter than 5 years was done in a significantly smaller number of patients in whom cement was used. (7.6% in cemented versus 14.8% in uncemented THA).

Zhou et al.<sup>8</sup> studied 224 patients who underwent THA for osteoporotic femoral neck fracture. Of those, 114 underwent THA without cement and 110 with cement. The average follow-up was 5 years. In the second group, the results were significantly better than in the first, regarding HHS (75 vs 80), frequency of revision (14.0% vs. 5.5%), loosening (20.2% vs. 10.0%) and periprosthetic fracture (12.3% vs. 4.5%).

### **Studies which focused on Dorr femur types and supported the use of cementless THA in Dorr type C femora, without comparison between cementless and cemented THA**

Seven studies focused on Dorr femur types and supported the use of cementless THA in Dorr type C femora<sup>9-15</sup> (Table 1). The study by Zhen et al.<sup>9</sup> included 25 patients older than 60 years with Dorr type C femur who underwent cementless THA with a long-straight cylindrical tapered stem. The median follow-up was 125 months. At the final follow-up,

the HHS was markedly improved, and the radiological control showed good osseointegration of the prostheses.

McLaughlin and Lee<sup>10</sup> also investigated the use of a cementless femoral prosthesis in THA of patients with Dorr femur type C, compared with patients with Dorr femur type A and B. The total number of patients was 320. After a mean follow-up time of 16.6 years, osteolysis was found in only 3.3% of cases of Dorr femoral type C, while in patients with type A and B the rate was 4%. There was no aseptic loosening in any case of Dorr type C patients and the HHS was markedly improved at final follow-up.

Kim et al.<sup>11</sup> compared the use of cementless THA with a proximally coated (with plasma-sprayed pure titanium) single-wedge stem in patients with the 3 Dorr types of femoral canal. The authors studied 307 total hip arthroplasties in 247 patients with a mean follow-up of 13.2 years. Postoperatively, the 3 groups did not differ significantly clinically (in terms of HHS) and radiologically, and in terms of periprosthetic fractures and osteolysis.

Zhen et al.<sup>12</sup> investigated 42 cementless total hip arthroplasties using a short femoral prosthesis in 35 young patients aged 20 to 36 years. The underlying diseases were: rheumatoid arthritis in 20 patients, ankylosing spondylitis in 10 patients and osteoarthritis in 5 patients. In all 42 cases, the femur was classified as Dorr type C. At a mean follow-up of 5.5 years, the HHS showed considerable improvement. Radiological examination revealed satisfactory osseointegration of the prostheses after the follow-up of these patients.

Ahmad Hatem et al.<sup>13</sup> investigated the outcomes of the use of cementless THA in patients with femur of the 3 Dorr types (A, B and C). 87 patients (90 hips) with a mean follow-up of 2.8 years were studied, while 32 femurs were type A (37%), 37 type B (42%) and 18 type C (21%). The HHS was markedly improved for all types. None of the 87 hips underwent revision and there were insignificant differences in clinical outcomes and osseointegration between the femurs of the 3 Dorr types.

The study by Syed et al.<sup>14</sup> included 176 patients over 70 years of age who underwent cementless THA with a collared hydroxyapatite-coated femoral prosthesis. The follow-up time was 1 year. There were patients with femur of all 3 Dorr types. The authors concluded that Dorr type had no effect on the risk of periprosthetic fracture or subsidence of the prosthesis.

Rattanaprichavej et al.<sup>15</sup> investigated 311 patients who underwent cementless THA with a hydroxyapatite-coated femoral prosthesis. Patients were followed for at least 2 years postoperatively (mean follow up: 44.1 months). It was found that type B and C femurs showed a statistically insignificant difference in subsidence compared with type A.

### ***Studies which focused on Dorr femur types and did not support the use of cementless THA in Dorr type C femora***

Four studies focused on Dorr femur types and did not support the use of cementless THA in Dorr type C femora<sup>16-19</sup> (Table 2). Tsubosaka et al.<sup>16</sup> analyzed the use of cementless THA in 90 patients with a mean follow-up time of 5 years. The 3 different Dorr types of femur were compared in these patients. Although, overall, the HHS was significantly increased after surgery, there were insignificant differences both preoperatively and postoperatively in these 3 Dorr types. However, stress shielding in patients with a Dorr type C femur compared to those with a type B led to the conclusion that the use of this femoral prosthesis should be used with caution in patients with a Dorr type C femur.

Kheir et al.<sup>17</sup> performed a multicentered retrospective study on 709 THA cases (199 cemented, 510 cementless) for femoral neck fractures, with mean follow-up of 2.7 years. The three Dorr types of femur (A, B and C) were associated with a periprosthetic femoral fracture rate of 2.3%, 3.7%, and 15.9% respectively for cementless implants. All periprosthetic femoral fractures occurred in cementless cases.

Gromov et al.<sup>18</sup> studied retrospectively 1598 hips in 1441 patients who underwent cementless THA with a proximally plasma sprayed titanium alloy cementless femoral component. The mean follow-up was 713 days. It was found that patients with femur Dorr type C had a 5.2 times higher risk of postoperative periprosthetic fracture compared with type B.

Gkagkalis et al.<sup>19</sup> compared the clinical and radiological outcomes, as well as the perioperative complications, of the use of cementless THA with a short femoral prosthesis in 2 groups. A total of 400 femoral prostheses in 360 patients were used. One group included patients younger than 60 years, and the other included patients older than 75 years. The mean follow-up time was 49.2 months. The 2 groups showed a statistically non-significant difference, both in terms of clinical and radiological results. However, it was found that in elderly patients with type C femurs there was a much higher incidence of periprosthetic fractures.

### ***Other studies which investigated the use of cementless THA implants in osteoporotic patients or Dorr types of femur***

There were four more studies which investigated the use of cementless THA implants in osteoporotic patients or Dorr types of femur<sup>5,20-22</sup>. Ikemura et al.<sup>5</sup> retrospectively reviewed 104 hips in 100 patients with Dorr type C femur who underwent cementless THA either with a fit-and-fill stem or with a tapered wedge femoral stem. The authors calculated the stem subsidence 6 weeks postoperatively for the two groups and found the tapered wedge stem more suitable for Dorr type C femora than the fit-and-fill stem.

Hopman et al.<sup>20</sup> investigated the effect of sex, age, presence of osteoporosis, and Dorr femoral type on the risk of periprosthetic fracture, 4 months postoperatively, in 2635 patients who underwent cementless THA. The authors concluded that the risk was significantly greater for women over 75 years of age, but although women in this age group would be expected to have osteoporosis, the presence of osteoporosis and Dorr femur type were not found to be significantly associated with this risk.

The study by Seo et al.<sup>21</sup> included 70 patients with age higher than 65 years, who suffered from femoral neck fracture and osteoporosis. Among them, 34 underwent cementless THA and in 36 cementless hemiarthroplasty was performed. The mean follow-up was 28.4 months. The mean HHS postoperatively was significantly higher for the THA group. There was no revision surgery until the final follow-up and only one case of prosthesis subsidence was noted.

Finnila et al.<sup>22</sup> investigated the effect of BMD on the loosening of cementless acetabular prostheses in women who underwent THA. The study involved 34 women with an average age of 64 years. Patients were followed up radiologically for a mean of 8 years. Ten women had normal BMD and 24 had low BMD (osteopenia or osteoporosis). No cases of osteolysis and loosening were observed. It was found that patients with low BMD showed persistent proximal migration of the acetabular prosthesis between 3-12 months after surgery, which was not observed in patients with normal BMD, but, finally, osseointegration took place.

### ***Studies which investigated the use of medication in osteoporotic patients who underwent THA***

Three studies evaluated that use of medication in osteoporotic patients who underwent THA<sup>23-25</sup>. In all three studies the procedure was cementless.

Fu et al.<sup>23</sup> performed a study in which they included 81 patients who underwent cementless THA and were divided into 3 groups: normal BMD, osteopenia, and osteoporosis. The mean follow-up time was 1.3 years. Osteoporosis patients were treated with zoledronate, calcium and vitamin D. Patients with osteopenia received daily only calcium and vitamin D. It was concluded that zoledronate, and not only calcium and vitamin D, could impede the accelerated



periprosthetic bone loss after THA in osteopenic and osteoporotic patients.

Nagoya et al.<sup>24</sup> evaluated the effect of the use of denosumab in the BMD of osteoporotic women with age higher than 70 years old, who underwent cementless THA. Ten patients received denosumab, while 10 patients received only vitamin D daily after surgery. In the first group, there was a mean increase of 2.5% at 6 months postoperatively and of 7.3% at 1 year postoperatively at the periprosthetic BMD in the proximal medial femur (zone 7). In contrast, in the control group, there was a mean decrease of 16.5% at 6 months postoperatively and 23.1% at 1 year postoperatively.

Finnila et al.<sup>25</sup> included in their study 57 postmenopausal women who underwent cementless THA and were allocated to receive either denosumab or only calcium and vitamin D postoperatively. At 48 weeks postoperatively, osteopenic and osteoporotic women showed significantly greater stem subsidence than women with normal BMD. It was also found that denosumab resulted in significant decrease of the variance of stem migration in osteopenic and osteoporotic women.

## Discussion

Overall, the research on the outcomes (HHS, periprosthetic bone loss, periprosthetic fractures, prosthesis subsidence and revision rate) of cemented or cementless THA is relatively limited in patients who were stated to be osteoporotic (seven papers), compared to the research on patients with Dorr type C femur (12 papers). Of note, there is paucity of studies to compare the outcomes between cemented and cementless THA in osteoporotic patients. Yang et al.<sup>7</sup> and Zhou et al.<sup>8</sup> found that cemented THA led to significantly less complications rate than cementless THA, while the former resulted in better clinical outcomes than the latter. No further comparative studies were found; hence such studies are essential to clarify whether cemented or cementless THA is indicated for osteoporotic patients. Although several authors performed studies to evaluate the clinical and radiological outcomes of cementless THA<sup>5,9-25</sup>, there was lack of studies to investigate those outcomes in cemented THA.

In the papers which focused on uncemented THA<sup>5,9-25</sup>, conflicting results were pointed out. More specifically, seven studies<sup>9-15</sup> showed that cementless THA could not be considered a contraindication for patients with Dorr type C bone, which is typically correlated with osteoporosis<sup>4,5</sup>. Two out of those studies<sup>9,12</sup> evaluated only the outcomes of the use of uncemented THA in patients with Dorr type C femur. There were also studies which explored the clinical scores, periprosthetic fracture rate, revision rate, prosthesis subsidence and loosening in patients who underwent cementless THA and had a Dorr type C femur, versus those who had type A or B femur, and found insignificant differences at all fields which were investigated<sup>10,11,13-15</sup>. It should be noted that, in the study by Ahmad Hatem et al.<sup>13</sup>, who did not

find revision cases in any Dorr femur type, the mean follow-up was relatively limited (2.8 years). In another study with relatively limited mean follow-up (1 year)<sup>14</sup>, the Dorr femur type had no effect on the risk of periprosthetic fracture or subsidence of the cementless THA prosthesis, although the risk for fractures is higher in osteoporotic patients. Of note, three studies of the review had a mean follow-up higher than 10 years<sup>9-11</sup> and consistently found encouraging outcomes of cementless THA in patients with osteoporosis or Dorr type C femur. However, those encouraging outcomes should be interpreted with caution, because comparison with cemented THA was not performed.

In contrast, there were four studies<sup>16-19</sup> in which the outcomes of cementless THA in patients with Dorr type C femur were unsatisfactory, compared with patients with types A and B. Among those studies, one<sup>16</sup> found only increased stress shielding in Dorr type C femora, without further complications, while the clinical scores were insignificantly different among the three types of femora. In the remaining three studies<sup>17-19</sup>, the main concern of the use of uncemented THA in Dorr type C femora was the higher periprosthetic fracture rate in comparison with types A and B. In one of those three studies<sup>16</sup>, however, the clinical and radiological outcomes were insignificantly different among the types A, B and C.

It should be noted that most of the research related to cementless THA in osteoporotic patients focused on Dorr type C femora and comparison of outcomes between type C and type A or B. Only one study<sup>22</sup> investigated the outcomes (only radiological) of an uncemented acetabular cup in osteopenic or osteoporotic patients, in comparison with those with normal BMD. Although proximal migration of the acetabular cups was noted in the former group, the final outcomes were overall satisfactory, because osseointegration finally took place, while neither osteolysis nor loosening were observed.

There was only one study<sup>5</sup> which compared two different types of femoral stems. Ikemura et al.<sup>5</sup> found that, in the case of cementless THA, the tapered wedge femoral stem is more suitable for patients with Dorr type C femur than the fit-and-fill stem. In fact, the role of the type of femoral or acetabular prosthesis in cementless or cemented THA in osteoporotic patients has not been adequately explored. Zhen et al.<sup>12</sup> and Gkagkalis et al.<sup>19</sup> focused on the use of short femoral stems in patients with Dorr type C femur, who underwent cementless THA. In the study by Zhen et al.<sup>12</sup>, which included relatively young patients, the outcomes were satisfactory. However, in the study by Gkagkalis et al.<sup>19</sup>, which comprised elderly patients, it was found that the short femoral stem was accompanied by high incidence of periprosthetic fractures. Also, possible coating with hydroxyapatite may play a role in the improvement of outcomes related with cementless THA in patients with Dorr type C femora. Syed et al.<sup>14</sup> and Rattanaprichavej et al.<sup>15</sup>, who investigated the use of hydroxyapatite-coated femoral stems in cementless

THA of patients with Dorr type C femora found insignificantly different outcomes compared to other Dorr types. The role of coating with hydroxyapatite, as well as the design of femoral or acetabular prostheses, are possible fields of future research for osteoporotic patients with either cementless or cemented THA.

In terms of the role of anti-osteoporotic drugs in the prevention of periprosthetic bone loss, up to 1.3 years postoperatively, in osteoporotic patients with THA, three studies<sup>23-25</sup> found positive results of the use of those drugs. This review, which focused on osteoporotic patients, confirmed that such medication has been proved favorable for those individuals, although the number of relative studies is limited. There was no study to show that the use of such drugs was not effective. More specifically, Fu et al.<sup>23</sup> investigated the role of zoledronate, while Nagoya et al.<sup>24</sup> and Finnila et al.<sup>25</sup> explored the role of denosumab. Those three studies comprised osteoporotic patients who underwent cementless THA. While Fu et al.<sup>23</sup> and Nagoya et al.<sup>24</sup> focused on the measurement of BMD and showed that it was increased, Finnila et al.<sup>25</sup> calculated the stem migration and found that denosumab decreased this migration. The results of those three studies are encouraging and may stimulate further research to investigate if the use of anti-osteoporotic drugs can reduce the incidence of complications of cementless or cemented THA in patients with osteoporosis.

This study has some limitations. The search in the specific databases with certain key words, inclusion and exclusion criteria may have been insufficient to locate the full spectrum of papers which investigated the use of cemented or cementless THA in osteoporotic patients. Also, the small number of papers which directly compared the outcomes between cemented and uncemented THA in those patients did not permit the performance of a meta-analysis. It is expected that future research, comprising comparative studies, will allow such meta-analysis and shed more light on the role of each type of THA in the management of patients suffering from osteoporosis.

## Conclusion

The research about the outcomes of cemented or cementless THA in osteoporotic patients is characterized by paucity of comparative studies. The limited number of comparative studies showed that cemented THA led to better outcomes than cementless THA. The papers which evaluated only the use of uncemented THA in patients with osteoporosis or Dorr type C bone showed conflicting outcomes, although most of those articles showed that cementless THA led to satisfactory results and may not be contraindicated for those patients. There is need for higher number of studies to compare the results of the use of cemented versus cementless THA in the case of osteoporosis or Dorr type C bone.

## Disclaimer

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