Actas Urológicas Españolas 48 (2024) 79–104

Actas Urológicas Españolas

www.elsevier.es/actasuro

REVIEW ARTICLE

Kidney stones in renal transplant recipients: A systematic review

A. Piana[a,b,*,1], G. Basile[c,1], S. Masih[d], G. Bignante[b], A. Uleri[c], A. Gallioli[c], T. Prudhomme[e], R. Boissier[f], A. Pecoraro[g], R. Campi[g], M. Di Dio[h], S. Alba[a], A. Breda[c], A. Territo[c], en representación del grupo de trabajo de trasplante renal de la sección de Jóvenes Urólogos Académicos (YAU) de la Asociación Europea de Urología (EAU)

[a] *Servicio de Urología, Hospital Romolo, Rocca di Neto, Italy*
[b] *Departamento de Urología, Universidad de Turín, Turín, Italy*
[c] *Unidad de Uro-oncología y Trasplante Renal, Servicio de Urología, Fundación Puigvert, Universidad Autónoma de Barcelona (UAB), Barcelona, Spain*
[d] *Servicio de Urología, Centro Médico de la Universidad de Toledo, Toledo, OH, United States*
[e] *Servicio de Urología, Trasplante Renal y Andrología, Hospital Universitario de Rangueil, Toulouse, France*
[f] *Servicio de Urología y Trasplante Renal, Hospital Universitario La Concepción, Marsella, France*
[g] *Departmento de Medicina Experimental y Clínica, Universidad de Florencia, Florencia, Italy*
[h] *Sección de Urología, Servicio de Cirugía, Hospital Annunziata, Cosenza, Italy*

Received 21 April 2023; accepted 10 July 2023
Available online 12 August 2023

KEYWORDS
Kidney transplantation;
Urolithiasis;
Treatment

Abstract

Introduction: Lithiasis in renal graft recipients might be a dangerous condition with a potential risk of organ function impairment.

Evidence acquisition: A systematic literature search was conducted through February 2023. The primary objective was to assess the incidence of lithiasis in kidney transplant (KT) recipients. The secondary objective was to assess the timing of stone formation, localization and composition of stones, possible treatment options, and the incidence of graft loss.

Evidence synthesis: A total of 41 non-randomized studies comprising 699 patients met our inclusion criteria. The age at lithiasis diagnosis ranged between 29–53 years. Incidence of urolithiasis ranged from 0.1–6.3%, usually diagnosed after 12 months from KT. Most of the stones were diagnosed in the calyces or in the pelvis. Calcium oxalate composition was the most frequent. Different treatment strategies were considered, namely active surveillance, ureteroscopy, percutaneous/combined approach, or open surgery. 15.73% of patients were submitted to extracorporeal shock wave lithotripsy (ESWL), while 26.75% underwent endoscopic

DOI of original article: https://doi.org/10.1016/j.acuro.2023.07.003
* Corresponding author.
E-mail addresses: alb.piana@gmail.com, alberto.piana@unito.it (A. Piana).
[1] These authors have contributed equally to the development of this work.

https://doi.org/10.1016/j.acuroe.2023.08.003

lithotripsy or stone extraction. 18.03% of patients underwent percutaneous nephrolithotomy whilst 3.14% to a combined approach. Surgical lithotomy was performed in 5.01% of the cases. Global stone-free rate was around 80%.
Conclusions: Lithiasis in kidney transplant is a rare condition usually diagnosed after one year after surgery and mostly located in the calyces and renal pelvis, more frequently of calcium oxalate composition. Each of the active treatments is associated with good results in terms of stone-free rate, thus the surgical technique should be chosen according to the patient's characteristics and surgeon preferences.

PALABRAS CLAVE
Trasplante renal;
Urolitiasis;
Tratamiento

Litiasis en receptores de trasplante renal: revisión sistemática

Resumen
Introducción: La litiasis en el receptor del injerto renal puede ser una enfermedad peligrosa cuyo riesgo potencial es el deterioro de la función renal.
Adquisición de la evidencia: Se realizó una búsqueda sistemática de la literatura hasta febrero de 2023. El objetivo primario era evaluar la incidencia de litiasis en receptores de trasplante renal (TR). El objetivo secundario era evaluar el momento de formación, la localización y la composición de la litiasis, las opciones de tratamiento disponibles y la incidencia de la pérdida del injerto.
Síntesis de la evidencia: Un total de 41 estudios no aleatorizados compuestos por 699 pacientes cumplieron los criterios de inclusión. La edad en el momento del diagnóstico de litiasis oscilaba entre 29 y 53 años. La incidencia de urolitiasis se encontraba entre el 0,1 y 6,3%, siendo diagnosticada generalmente a los 12 meses del TR. La mayoría de litiasis diagnosticadas se localizaron en los cálices o en la pelvis. La composición más frecuente fue la de oxalato cálcico. Se consideraron diferentes estrategias de tratamiento como vigilancia activa, ureteroscopia, abordaje percutáneo/combinado o cirugía abierta. Del total de pacientes, 15,73% fueron sometidos a litotricia extracorpórea por ondas de choque (LEOCh) y 26,75% se sometieron a litotricia endoscópica o extracción quirúrgica. De estos sujetos, 18,03% se abordaron mediante nefrolitotomía percutánea, mientras que el 3,14% se sometieron a un abordaje combinado. Se realizó litotomía quirúrgica en 5,01% de los casos. La tasa libre de litiasis (TLL) global se situó en torno al 80%.
Conclusiones: La litiasis en el trasplante renal es una patología poco frecuente que suele diagnosticarse al año de la cirugía. Su localización más frecuente son los cálices y la pelvis renal, y en la mayoría de los casos está compuesta de oxalato cálcico. Todos los tratamientos activos han demostrado resultados satisfactorios en términos de TLL, por lo que la elección de la técnica quirúrgica se debe basar en las características del paciente y las preferencias del cirujano.

Introduction

Renal transplant graft lithiasis might be a dangerous scenario with a potential risk of organ failure and graft loss.[1,2] In fact, due to the partial denervation of the graft, the typical cholic flank pain associated with lithiasis formation may be missed, leading to a late diagnosis of graft hydronephrosis and functional impairment. Furthermore, it is a challenging condition because it involves a single-functioning kidney in patients who often have high comorbidity status that can lead to severe complication as sepsis. Treatment of de novo lithiasis in kidney transplant (KT) recipients also presents many technical challenges owing to the heterotopic position of the renal graft on the iliac vessels and the diverse urinary anastomosis techniques. Only small and retrospective series are available in the Literature reporting the incidence and characteristics of urolithiasis in transplanted kidneys.[3] Consequently, there is a lack of high-level evidence regarding the correct management of these patients. Therefore, we performed a systematic review to assess the incidence of lithiasis in KT recipients, the type of stone composition, and the more frequent used treatment.

Materials and methods

Search strategy

We conducted a systematic review in line with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines[4] (Fig. 1). This protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) database (Registration Number: CRD42023409259). The literature search was performed in PubMed/Medline, Embase, and Web of

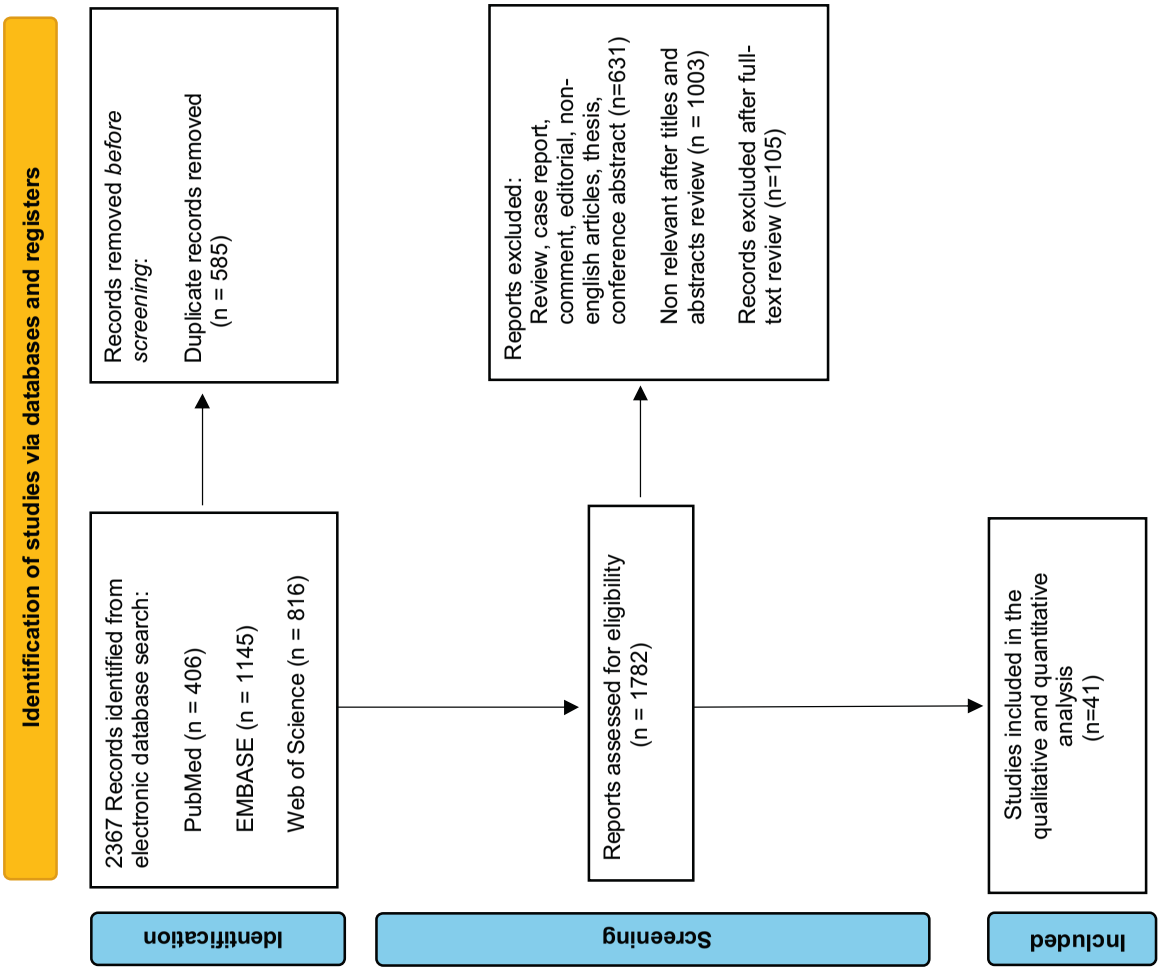

Figure 1 Prisma flow chart – study selection with inclusion and exclusion criteria of the reviewed studies.

Science databases, to identify reports published through February 2023 reporting on lithiasis of kidney transplant recipients. The search strategy used the combination of the following terms grouped according to the Boolean operators (AND, OR, NOT): kidney transplant, renal transplant, stone, lithiasis. The primary objective of this systematic review is to assess the incidence of lithiasis in kidney transplant (KT) recipients. The secondary objective is to assess the timing of stone formation, localization and composition of stones, possible treatment options, and the incidence of graft loss.

Study selection

Studies were deemed eligible if they included patients who underwent renal transplantation developing urolithiasis in the graft (P), submitted to active treatment (I) or conservative management (C) in order to assess the incidence of lithiasis, the time of stone formation, the composition of the stone, peri-operative outcomes, and graft loss (O). All articles with data of interest were selected: only those articles pertinent with PICO strategy, full text in English were included. Abstracts, editorials, commentaries, reviews, book chapters, non-English language, single case reports and articles reporting experimental studies on animals or cadavers were excluded.

Data extraction

The articles were independently reviewed by two of the authors (A.P. and G.B.) on the basis of inclusion and exclusion criteria. Titles and abstracts were analyzed. After this initial screening, a full-text review was conducted to confirm the selected articles' eligibility for inclusion. Finally, references from the selected articles were reviewed in order to identify other possible sources of data. Disagreements regarding study selection were resolved by a third reviewer (A.T.).

Risk-of-Bias assessment

The risk of bias assessment was performed independently by two authors (T. P. and A.P.) using the Prediction Model Study Risk of Bias Assessment Tool (PROBAST).[5] The eventual disagreement was solved by a third author (A. T.). The risk of bias was measured over four domains of interest (participants, predictors, outcome, and analysis) (Fig. 2).

Data extraction and analysis

Baseline demographics (age, body mass index, prostate specific antigen (PSA), cause of end stage renal disease (ESRD)), peri-operative variables (operating time, estimated blood losses [EBL], complications, length of stay), postoperative complications (>30 post-operative days) were recorded whenever available.

Evidence synthesis

Study characteristics

The Literature search included 2367 records. After screening and eligibility assessment, 41 studies met the inclusion criteria. In total, 699 KT recipients with urolithiasis were included with an age at the diagnosis ranging between 29 and 53 years-old.[6,7] Table 1

Figure 2 Evaluation of the risk of bias and confounders.

Table 1 Characteristics of studies included in the systematic review.

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Abbott et al. (2003) [14]	52	1994—1998	40.8+/-15.6	0.1	NA	NA	NA	- Extracorporeal lithotripsy: 1 (2) - Ureteroscopy: 7 (14) - Percutaneous nephrolitho-tomy: 19 (37) - Unknown: 25 (48)	- Renali failure: 1 (2)	NA	1 (2)	NA
Basiri et al. (2006) [15]	6	1989—2002	NA	0.4	NA	NA	NA	- Ureteroscopy: 4 (67) - Percutaneous nephrolitho-tomy: 1 (17) - Surgical litothomy: 1 (17)	- Urinary leakage: 1 (17) - Urinary tract infection: 1 (17)	NA	NA	NA
Benoit et al. (1996) [13]	12	1976—1992	40.3 (30—50)	0.8	NA	- Struvite: 2 (17) - Mixed: 4 (33) - Unknown: 6 (50)	- Calix: 5 (42) - Ureteropelvic junction: 1 (8) - Urether: 6 (50)	- Extracorporeal lithotripsy: 1 (8) - Ureteroscopy: 2 (17) - Surgical litothomy: 5 (42) - Other combined approach: 1 (8) - Surveillance: 3 (25)	NA	NA	NA	NA

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Bolen et al. (2022) [12]	56	2009–2019	NA	0.9	12 (0–384)	- Calcium oxalate: 6 (9) – Monohydrate: 0 (0) – Dihydrate: 0 (0) – Unknown: 6 (9) - Calcium phosphate: 1 (2) - Mixed: 5 (9) - Unknown: 44 (79)	- Upper pole calix: 8 (14) - Middle pole calix: () - Lower pole calix: 20 (36) - Renal pelvis: 6 (11) - Urether: 9 (16) - Multiple: 5 (9) - Unknown: 8 (14)	- Ureteroscopy: 19 (34) - Percutaneous nephrolithotomy: 7 (12) - Unknown: 2 (4) - Surveillance: 28 (50)	NA	NA	0	NA
Branchereau et al. (2018) [38]	95	NA	48	NA	40	NA	- Upper pole calix: 7 (7) - Middle pole calix: 3 (3) - Lower pole calix: 27 (28) - Renal pelvis: 14 (15) - Ureteropelvic junction: 16 (17) - Urether: 28 (29)	- Extracorporeal lithotripsy: 12 (13) - Ureteroscopy: 25 (26) - Percutaneous nephrolithotomy: 10 (11) - Surgical litothomy: 2 (2) - Surveillance: 46 (47)	- Perinephric haematoma: 8 (8) - Ureteroneocistostomy stenosis: 11 (12) - Transplant phyelonephritis: 2 (2)	0	0	- Extracorporeal lithotripsy: 6/12 (50) - Ureteroscopy: 21/25 (84) - Percutaneous nephrolithotomy: 9/10 (90) - Surgical litothomy: 2/2 (100)

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Buresley et al. (2008) [11]	1	1993–2005	NA	0.2	7	NA	NA	- Extracorporeal lithotripsy: 1 (100)	NA	NA	0	(100)
Challacombe et al. (2005) [16]	21	1997–2003	43 (15–63)	1.0	43 (6–216)	NA	NA	- Extracorporeal lithotripsy: 12 (57) - Percutaneous nephrolithotomy: 6 (29) - Surgical litothomy: 1 (5) - Surveillance: 2 (10)	NA	- Lithiasis relapsing: 1 (5)	0	(100)
Cho et al. (1988) [17]	9	1972–1986	30 (8–65)	1.7	7 (3–42)	- Calcium oxalate: 2 (22) – Monohydrate: 1 (11) – Dihydrate: 0 (0) – Unknown: 1 (11) - Calcium phosphate: 2 (22) - Uric acid: 1 (11) - Struvite: 2 (22) - Unknown: 2 (22)	- Renal pelvis: 3 (33) - Bladder: 4 (45) - Unknown: 2 (22)	- Cystoscopic lithotripsy/extraction: 3 (33) - Percutaneous nephrolithotomy: 1 (11) - Surgical litothomy: 3 (33) - Surveillance: 2 (22)	NA	NA	- Chronic rejection: 1 (11)	NA

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Cicerello et al. (2014) [18]	10	1995–2012	43 (31–59)	1.0	NA	NA	- Upper pole calix: 2 (20) - Middle pole calix: 1 (10) - Lower pole calix: 2 (20) - Renal pelvis: 1 (10) - Ureteropelvic junction: 1 (10) - Urether: 2 (20) - Ureterovescical junction: 1 (10)	- Extracorporeal lithotripsy: 1 (10) - Ureteroscopy: 6 (60) - Percutaneous nephrolithotomy: 2 (20) - Surgical litothomy: 1 (10)	NA	NA	0	- Extracorporeal lithotripsy: 1/2 (50) - Ureteroscopy: 1/7 (14)
Del Pizzo et al. (1998) [19]	4	1991–1996	NA	0.7	NA	NA	- Urether: 1 (25) - Ureterovescical junction: 3 (75)	- Ureteroscopy: 4 (100)	NA	NA	0	- Ureteroscopy: 4/4 (100)
Doehn et al. (2002) [20]	11	1985–2000	50	0.7	NA	- Calcium oxalate: 3 (27) – Monohydrate: 0 (0) – Dihydrate: 0 (0) – Unknown: 3 (27) - Uric acid: 3 (27) - Struvite: 2 (19) - Unknown: 3 (27)	NA	- Extracorporeal lithotripsy: 3 (27) - Percutaneous nephrolithotomy: 5 (46) - Surveillance: 3 (27)	NA	- Lithiasis relapsing: 2 (19) - Chronic rejection: 1 (9)	0	(100)

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Emiliani et al. (2018) [21]	51	1983—2017	49 (26—70)	2.4	31 (10—63)	- Calcium oxalate: 8 (16) — Monohydrate: 7 (14) — Dihydrate: 1 (2) — Unknown: 0 (0) - Calcium phosphate: 4 (8) - Uric acid: 6 (12) - Struvite: 5 (10) - Mixed: 1 (2) - Unknown: 27 (53)	- Upper pole calix: 2 (4) - Middle pole calix: 2 (4) - Lower pole calix: 9 (18) - Renal pelvis: 4 (8) - Ureteropelvic junction: 2 (4) - Urether: 30 (59)	- Extracorporeal lithotripsy: 22 (43) - Ureteroscopy: 9 (18) - Percutaneous nephrolithotomy: 4 (8) - Surgical litothomy: 2 (4) - Surveillance: 14 (27)	- Haematuria: 2 (4) - Urinary tract infection: 3 (6) - Sepsis: 1 (2)	- Lithiasis relapsing: 4 (8)	0	- Extracorporeal lithotripsy: 20/22 (91) - Ureteroscopy: 9/9 (100) - Percutaneous nephrolithotomy: 4/4 (100) - Surgical litothomy: 1/2 (50)

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Ferreira Cassini et al. (2012) [22]	17	1968–2011	46 (32–63)	1.3	NA	NA	- Calix: 9 (53) - Renal pelvis: 3 (18) - Urether: 5 (29)	- Extracorporeal lithotripsy: 6 (35) - Ureteroscopy: 3 (18) - Percutaneous nephrolitho-tomy: 1 (6) - Surgical litothomy: 2 (12) - Surveillance: 5 (29)	0	0	0	NA
Friedersdorff et al. (2017) [23]	8	2002–2014	NA	0.4	(2–98)	- Calcium oxalate: 1 (12) – Monohydrate: 0 (0) – Dihydrate: 0 (0) – Unknown: 1 (12) - Calcium phosphate: 1 (12) - Mixed: 3 (38) - Unknown: 3 (38)	- Lower pole calix: 1 (12) - Renal pelvis: 1 (12) - Urether: 2 (25) - Multiple: 3 (38) - Unknown: 1 (12)	- Ureteroscopy: 2 (25) - Percutaneous nephrolitho-tomy: 2 (25) - Other combined approach: 4 (50)	- Urosepsis: 1 (12) - Blod loss: 1 (12) - Urether perforation: 1 (12)	0	0	- Extracor-poreal lithotripsy: 0/3 (0) - Ureteroscopy: 2/3 (66) - Percuta-neous nephrolitho-tomy: 2/2 (100)
Gerber et al. (2021) [6]	18	2009–2018	53.5	NA	NA	- Calcium oxalate: 2 (11) – Monohydrate: 2 (11) – Dihydrate: 0 (0) – Unknown: 0 (0) - Calcium phosphate: 1 (5) - Mixed: 2 (11) - Unknown: 13 (72)	- Kidney: 6 (33) - Urether: 6 (33) - Multiple: 6 (33)	- Ureteroscopy: 16 (89) - Combined endoscopic/ percutaneous: 2 (11)	- Urinary leakage: 1 (11) - Ipacted distal uretral stone: 1 (11)	0	0	- Ureteroscopy: 15/16 (94) - Combined endoscopic/ percuta-neous: 2/2 (100)

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Harper et al. (1994) [1]	6	1990–1991	NA	3.4	NA	- Calcium oxalate: 1 (17) – Monohydrate: 0 (0) – Dihydrate: 0 (0) – Unknown: 1 (17) - Calcium phosphate: 2 (33) - Uric acid: 1 (17) - Mixed: 1 (17) - Unknown: 1 (17)	- Renal pelvis: 2 (33) - Ureterovescical junction: 1 (17) - Bladder: 1 (17) - Unknown: 2 (33)	- Cystoscopic lithotripsy/ extraction: 2 (33) - Percutaneous nephrolitho-tomy: 2 (33) - Surveillance: 1 (17) - Unknown: 1 (17)	NA	NA	NA	NA
Harraz et al. (2017) [24]	16	1974–2009	41+/-12	1.3	NA	NA	- Upper pole calix: 3 (19) - Middle pole calix: 5 (31) - Lower pole calix: 3 (19) - Renal pelvis: 2 (13) - Urether: 3 (19) - Bladder: 6 (38)	- Extracorporeal lithotripsy: 3 (19) - Percutaneous nephrolitho-tomy: 11 (68) - Surveillance: 2 (13)	- Haematuria: 1 (6) - Urine leakage: 1 (6) - Intestinal obstruction: 1 (6)	0	0	- Extracor-poreal lithotripsy: 3/3 (100) - Percuta-neous nephrolitho-tomy: 11/11 (100)
Hayes et al. (1989) [7]	10	1977–1988	29 (17–53)	1.1	NA	NA	NA	- Extracorporeal lithotripsy: 1 (10) - Ureteroscopy: 3 (30) - Surgical litothomy: 1 (10) - Other combined approach: 1 (10) - Surveillance: 4 (40)	NA	NA	NA	NA

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
He et al. (2007) [39]	7	2002–2006	40.7	NA	36 (1–72)	- Calcium oxalate: 2 (29) – Monohydrate: 0 (0) – Dihydrate: 0 (0) – Unknown: 2 (29) - Uric acid: 2 (29) - Struvite: 1 (14) - Mixed: 2 (29)	- Renal pelvis: 3 (43) - Ureteropelvic junction: 1 (14) - Ureterovescical junction: 3 (43)	- Percutaneous nephrolithotomy: 7 (100)	0	0	0	(100)
Hyams et al. (2012) [40]	12	2006–2011	42 (36–72)	NA	87 (8–209)	- Calcium oxalate: 6 (50) – Monohydrate: 0 (0) – Dihydrate: 0 (0) – Unknown: 6 (50) - Calcium phosphate: 4 (33) - Struvite: 1 (8) - Unknown: 1 (8)	- Renal pelvis: 7 (58) - Urether: 3 (25) - Multiple: 2 (17)	- Ureteroscopy: 7 (58) - Percutaneous nephrolithotomy: 5 (42)	- Nephrocutaneous fistula: 1 (8)	- Uretral stent encrustation: 1 (8)	0	NA
Khositseth et al. (2004) [8]	20	1896–2003	9.2+/-4.7	5.0	19 (2–72)	- Calcium oxalate: 2 (10) – Monohydrate: 0 (0) – Dihydrate: 0 (0) – Unknown: 2 (10) - Calcium phosphate: 6 (30) - Struvite: 2 (10) - Mixed: 1 (5) - Unknown: 9 (45)	- Renal pelvis: 1 (5) - Ureterovescical junction: 8 (40) - Bladder: 7 (35) - Multiple: 2 (10) - Suture line: 2 (10)	- Cystoscopic lithotripsy/ extraction: 11 (55) - Surgical litothomy: 4 (20) - Surveillance: 4 (20) - Unknown: 1 (5)	- Lymphocele 1 (5) - Partial UVJ obstruction 1 (5) - Urethral stricture 2 (10) - Ureteral stump necrosis 1 (5) - Urinary tract infection 8 (40)	NA	NA	NA

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Kim et al. (2001) [25]	15	1980–1997	41.5 (28–67)	1.8	17.8 (3–109)	- Calcium oxalate: 1 (7) — Monohydrate: 0 (0) — Dihydrate: 0 (0) — Unknown: 1 (7) - Calcium phosphate: 3 (20) - Struvite: 2 (14) - Mixed: 7 (46) - Unknown: 2 (14)	- Renal pelvis: 3 (20) - Bladder: 11 (73) - Multiple: 1 (7)	- Cystoscopic lithotripsy/extraction: 8 (53) - Surveillance: 7 (47)	NA	- Lithiasis relapsing: 5 (33)	NA	(100)
Klingler et al. (2002) [26]	19	1993–2000	48 (26–72)	0.8	28 (13–48)	- Calcium oxalate: 11 (58) — Monohydrate: 0 (0) — Dihydrate: 0 (0) — Unknown: 11 (58) - Calcium phosphate: 1 (5) - Uric acid: 2 (11) - Unknown: 5 (26)	- Upper pole calix: 2 (11) - Middle pole calix: 8 (42) - Lower pole calix: 4 (21) - Ureteropelvic junction: 3 (15) - Urether: 1 (5) - Ureterovescical junction: 1 (5)	- Extracorporeal lithotripsy: 7 (37) - Ureteroscopy: 5 (26) - Percutaneous nephrolithotomy: 3 (16) - Other combined approach: 1 (5) - Surveillance: 3 (15)	- Uretral reimplantation: 1 (5)	- Permanent renal impairment: 1 (5)	NA	NA

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplanta-tion to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Krambeck et al. (2008) [41]	13	1988—2008	50 (16—71)	NA	33	- Calcium oxalate: 7 (54) — Monohydrate: 6 (46) — Dihydrate: 1 (7) — Unknown: 0 (0) - Calcium phosphate: 3 (23) - Uric acid: 1 (8) - Struvite: 1 (8) - Mixed: 1 (8)	- Lower pole calix: 1 (8) - Ureteropelvic junction: 9 (69) - Urether: 2 (15) - Multiple: 1 (8)	- Percutaneous nephrolitho-tomy: 13 (100)	- Sepsis: 1 (8)	- Herpes esophagitis: 1 (8) - Upper gas-trointestinal bleeding: 1 (8)	0	77

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Li et al. (2011) [45]	10	NA	34 (21–42)	NA	NA	NA	- Renal pelvis: 2 (20) - Urether: 8 (80)	- Extracorporeal lithotripsy: 7 (70) - Ureteroscopy: 2 (20) - Surgical litothomy: 1 (10)	0	0	0	- Extracorporeal lithotripsy: 7/7 (100) - Ureteroscopy: 2/2 (100) - Surgical litothomy: 1/1 (100)
Mahdavi et al. (2014) [27]	21	1989–2011	31	1.2	NA	NA	- Lower pole calix: 2 (10) - Renal pelvis: 8 (38) - Ureteropelvic junction: 1 (5) - Urether: 10 (48)	- Extracorporeal lithotripsy: 7 (33) - Ureteroscopy: 8 (38) - Percutaneous nephrolithotomy: 2 (10) - Other combined approach: 4 (11)	0	0	0	- Extracorporeal lithotripsy: 7/10 (70) - Ureteroscopy: 8/9 (88) - Percutaneous nephrolithotomy: 2/2 (100) - Other combined approach: 4/4 (100)

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Mamarelis et al. (2014) [28]	9	1983–2013	NA	0.4	37 (12–84)	NA	- Renal pelvis: 6 (66) - Urether: 3 (33)	- Extracorporeal lithotripsy: 3 (33) - Percutaneous nephrolithotomy: 3 (33) - Other combined approach: 1 (11) - Surveillance: 2 (22)	0	- Lithiasis relapsing: 2 (22)	0	- Extracorporeal lithotripsy: 3/3 (100)- Percutaneous nephrolithotomy: 3/3 (100) - Other combined approach: 1/1 (100)
Martin et al. (2007) [42]	5	2003–2005	(28–51)	NA	17	NA	- Upper pole calix: 3 () - Middle pole calix: 2 () - Lower pole calix: 2 ()	- Surveillance: 5 (100)	NA	NA	NA	NA

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Montanari et al. (2009) [29]	8	NA	NA	1.8	NA	- Calcium oxalate: 3 (38) — Monohydrate: 0 (0) — Dihydrate: 0 (0) — Unknown: 3 (38) - Struvite: 2 (25) - Mixed: 3 (38)	- Upper pole calix: 2 (25) - Lower pole calix: 2 (25) - Renal pelvis: 1 (12) - Ureteropelvic junction: 1 (12) - Urether: 1 (12) - Multiple: 1 (12)	- Extracorporeal lithotripsy: 8 (100)	0	0	0	- Extracorporeal lithotripsy: 8/8 (100)
Motayne et al. (1984) [9]	7	1965—1980	42 (23—57)	6.3	48 (6—72)	- Calcium oxalate: 1 (14) — Monohydrate: 0 (0) — Dihydrate: 0 (0) — Unknown: 1 (14) - Uric acid: 1 (14) - Mixed: 3 (43) - Unknown: 2 (29)	- Ureteropelvic junction: 2 (29) - Urether: 1 (14) - Multiple: 4 (57)	- Cystoscopic lithotripsy/extraction: 2 (29) - Surgical litothomy: 3 (42) - Other combined approach: 2 (29)	NA	NA	NA	NA
Oliveira et al. (2011) [43]	7	2000—2009	44	NA	66 (3—208)	NA	- Renal pelvis: 7 (100)	- Cystoscopic lithotripsy/extraction: 1 (14) - Percutaneous nephrolithotomy: 6 (86)	NA	NA	NA	6 (86)
Rezaee-Zavareh et al. (2015) [30]	31	1990—2010	NA	4.4	NA	NA	NA	NA	NA	NA	NA	NA

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Rhee et al. (1999) [31]	8	1984–1995	51 (34–60)	0.5	NA	- Calcium oxalate: 1 (12) – Monohydrate: 0 (0) – Dihydrate: 0 (0) – Unknown: 1 (12) - Calcium phosphate: 1 (12) - Uric acid: 1 (12) - Struvite: 1 (12) - Mixed: 1 (12) - Unknown: 3 (38)	- Renal pelvis: 3 (38) - Urether: 1 (12) - Bladder: 4 (50)	- Cystoscopic lithotripsy/extraction: 4 (50) - Extracorporeal lithotripsyy: 1 (12) - Ureteroscopy: 1 (12) - Other combined approach: 1 (12) - Surveillance: 1 (12)	0	- Lithiasis relapsing: 1 (12)	0	(100)
Sarier et al. (2019) [32]	22	2009–2017	41.6	1.0	27 (3–67)	NA	- Caliceal: 3 (14) - Renal pelvis: 7 (32) - Urether: 9 (41) - Bladder: 3 (14)	- Cystoscopic lithotripsy/ extraction: 3 (14) - Ureteroscopy: 18 (82) - Percutaneous nephrolitho-tomy: 1 (5)	0	0	0	- Cystoscopic lithotripsy/ extraction: 3/3 (100) - Ureteroscopy: 16/18 (89) - Percuta-neous nephrolitho-tomy: 1/1 (100)

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Sevinc et al. (2015) [33]	6	2008–2014	52 (31–65)	0.7	28 (17–58)	- Calcium oxalate: 3 (50) – Monohydrate: 0 (0) – Dihydrate: 0 (0) – Unknown: 3 (50) - Calcium phosphate: 1 (17) - Uric acid: 1 (17) - Unknown: 1 (17)	- Lower pole calix: 1 (17) - Urether: 4 (66) - Multiple: 1 (17)	- Ureteroscopy: 4 (66) - Percutaneous nephrolithotomy: 1 (17) - Other combined approach: 1 (17)	- Haematuria: 1 (17)	0	0	- Ureteroscopy: 4/4 (100) - Percutaneous nephrolithotomy: 1/2 (50) - Other combined approach: 1/1 (100)
Shoskes et al. (1995) [34]	2	1975–1991	NA	0.2	(12–60)	NA	- Urether: 1 (50) - Ureterovescical junction: 1 (50)	- Ureteroscopy: 2 (100)	NA	NA	0	- Ureteroscopy: 2/2 (100)
Stravodimos et al. (2012) [44]	7	1983–2007	NA	NA	38 (24–84)	NA	- Renal pelvis: 5 (71) - Urether: 2 (29)	- Extracorporeal lithotripsy: 3 (43)-Percutaneous nephrolithotomy: 3 (43) - Surveillance: 1 (14)	0	0	0	7 (100)

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Streeter et al. (2002) [35]	12	1975–1998	NA	0.8	5 (2–43)	NA	- Bladder: 3 (25) - Unknown: 9 (75)	- Cystoscopic lithotripsy/ extraction: 3 (25) - Extracorporeal lithotripsy: 1 (8) - Percutaneous nephrolithotomy: 3 (25) - Surgical litothomy: 1 (8) - Other combined approach: 1 (8) - Surveillance: 3 (25)	- Graft lost: 1 (8)	NA	1 (8)	8 (66)

Actas Urológicas Españolas 48 (2024) 79–104

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplanta-tion to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Verrier et al. (2012) [36]	31	1978–2010	41.5 (19–68)	1.0	102 (96–168)	NA	- Renal pelvis: 7 (23) - Urether: 16 (52) - Bladder: 4 (13) - Unknown: 4 (13)	- Cystoscopic lithotripsy/ extraction: 4 (13) - Extracorporeal lithotripsy: 2 (6) - Ureteroscopy: 3 (10) - Percutaneous nephrolitho-tomy: 2 (6) - Surgical litothomy: 8 (26) - Surveillance: 12 (33)	- Surgical failure: 2 (6)	0	0	- Extracor-poreal lithotripsy: 1/3 (33) - Ureteroscopy: 2/5 (40)

Table 1 (*Continued*)

Study first author (year)	Number of patients with lithiasis of the allograft included (number)	Recruitment period	Age on diagnosis of graft nephrolithiasis (years)	Prevalence of de novo nephrolithiasis (%)	Median time from renal transplantation to nephrolithiasis (months)	Stone composition [number (%)]	Stone localization [number (%)]	Treatment [number (%)]	Peri-operative complications (up to 30 postoperative days)	Long term complications due to nefrolithiasis (>30 postoperative days)	Graft loss due to the treatment number (%)	Stone free rate according to the treatment [number (%)]
Yigit et al. (2004) [37]	5	1999–2003	35+/-15.1	4.0	NA	- Calcium oxalate: 2 (40) – Monohydrate: 0 (0) – Dihydrate: 0 (0) – Unknown: 2 () - Uric acid: 1 (20) - Unknown: 2 (40)	NA	- Extracorporeal lithotripsy: 3 (60) - Ureteroscopy: 1 (20) - Other combined approach: 1 (20)	NA	NA	0	(100)
Yuan et al. (2015) [10]	19	2000–2014	39 (11–65)	1.2	21 (3–211)	- Calcium oxalate: 7 (37) – Monohydrate: 0 (0) – Dihydrate: 0 (0) – Unknown: 7 (37) - Uric acid: 2 (11) - Struvite: 3 (16) - Mixed: 2 (11) - Unknown: 5 (26)	- Renal pelvis: 9 (47) - Urether: 9 (47) - Multiple: 1 (6)	- Extracorporeal lithotripsy: 5 (26) - Ureteroscopy: 4 (21) - Percutaneous nephrolithotomy: 6 (32) - Other combined approach: 2 (11) - Surveillance: 2 (11)	- Blood loss: 1 (6) - Uretral perforation: 1 (6)	0	0	- Extracorporeal lithotripsy: 4/5 (80) - Ureteroscopy: 4/4 (100) - Percutaneous nephrolithotomy: 6/6 (100) - Other combined approach: 2/2 (100)

summarizes data extracted from each study. One of the studies included in this review was conducted on a pediatric population with a median age of 9.2 (standard deviation 4.7) years.[8] The study publication year varied considerably, ranging from 1984[9] to 2021.[6] In addition, all the studies included single-center retrospective cohorts.

Incidence, time of stone formation, localization, and composition of de novo graft lithiasis

The first objective of this review was the assessment of the incidence of urolithiasis in transplanted kidneys. 32/41 studies reported the incidence of graft lithiasis.[1,7–37] Data from included studies were heterogeneous. Emiliani et al.[21] reported an incidence of lithiasis of 2.4%, in contrast with Verrier et al. who showed a decreasing trend in the last 3 decades from 2.1% to 0.6%.[36] A percentage of 1.29% on a Brazilian population of 1313 patients was reported by Cassini et al.[22] Similarly, Kim et al. reported 1.8%.[25] Rhee et al. described an incidence of 0.23%[31] whilst Abbott et al.[14] observed the lowest rate of urolithiasis with an incidence of 0.15% (84.2/100.000) in females and 0.11% (59.9/100.000) in males. On the other hand, Motayne et al. reported the highest incidence (6.3%).[9] Similarly, Khositseth et al. observed a 5%[8] whilst a 4.4% was observed by Rezaee-Zavareh et al.[30] The other studies included in this review report incidence rates among the above-mentioned ranges.

Several studies do not report the time of the diagnosis of urolithiasis from renal transplantation or it was not clearly reported. In 24/41 studies,[8–12,16,17,21–23,25,26,28,32–36,38–44] the time of diagnosis exceeded 12 months with a maximum of 66 months from kidney transplantation.[43]

Considering the localization of the stones,[1,6,8–10,12,13,17–19,21–29,31–36,38–45] renal calyces are generally the most common localization, reaching more than 50% of the cases in several studies, such as those published by Montanari et al.,[29] Bolen et al.[12] and Harraz et al.[24] Conversely, Sarier et al.[32] observed 9/22 (41%) cases of ureteral lithiasis and Emiliani et al.[21] reported 30/51 (59%) cases. The incidence of bladder lithiasis was reported in Table 1 but it was not considered among the objectives of this review.

The composition of the stones in the graft, reported in 20/41 studies,[1,6,8–10,12,13,17,20,21,23,25,26,29,31,33,37,39–41] does not vary significantly among the included series, being calcium oxalate the most frequent finding in the studies included, whenever reported. Harper et al. observed 33% of calcium phosphate lithiasis (2/6 patients)[1] whilst Kim et al.[25] 20% (3/15 patients). Also Khositeth et al.[8] described a higher rate of calcium phosphate stones of 30% over the calcium oxalate. Uric acid lithiasis was preponderant over the other compositions, matching in incidence calcium oxalate in some of the studies considered.[1,9,20,31,39] Finally, struvite stones were less frequently observed with an incidence between 8–25%.

Treatment

Only 1/41 study did not report any treatment data.[30] Surveillance of intrarenal lithiasis was considered as an alternative to active treatment, except for Martin et al. where 100% (5/5 patients) of the patients were just observed.[42] Generally, active treatments were preferred in most of the cases, reaching 47% (46/95 patients) in the study from Branchereau et al.[38]

Overall, 110/699 (15.73%) patients were submitted to extracorporeal shock wave lithotripsy (ESWL). 187/699 (26.75%) patients underwent endoscopic lithotripsy or stone extraction. The biggest cohort of patients treated with ureteroscopy was described by Branchereau et al.,[38] who included 25/95 (26%) patients. 126/699 (18.03%) patients underwent percutaneous nephrolithotomy whilst in 22/699 (3.14%) a combined approach was preferred. Finally, surgical lithotomy was performed in 35/699 (5.01%) cases.

Stone free rate

In 14/41 studies,[6,10,11,16,18–21,23–25,27–29,31–39,41,43–45] the stone-free rate (SFR) after treatment was not reported. 16 (64.0%) studies stratified the stone-free rate after each treatment. In most of the cases, a highly successful rate was observed after endoscopic surgery as well as after percutaneous approaches. The global SFR was around 80%.

Complications and graft loss due to lithiasis

Perioperative complications (up to 30 post-operative days) were not reported in 17/41 studies. No complications were observed in 9 studies.[22,27–29,31,32,39,44,45] In the remaining 15 studies,[6,8,10,14,15,21,23,24,26,33,35,36,38,40,41] different complications were described, from hematuria to graft loss. In detail, hematuria was observed in 5 (19.2%) out of the 26 studies which reported perioperative complications. Urinary leakage was reported in 3 (11.5%) studies; infections in 15 (57.7%) with 3 (11.0%) episodes of sepsis; 2 (7.7%) cases of ureteral perforations; ureteral strictures were described in 15 (57.7%) cases, graft loss due to the treatment in 1 case (3.8%). Long-term complications (more than 30 postoperative days) were reported in 23/41 studies whilst no complications in 14/23 (60.9%). In the remaining 9 studies, lithiasis recurrence was described in 15 (65.2%) cases, chronic rejections and renal failure in 2 (8.7%).

Discussion

Kidney transplant is considered the standard treatment for end-stage renal disease (ESRD) leading to improved overall survival and a reduction of patient morbidity in comparison with dialysis.[46,47] The use of robotics[48–51] and the introduction of new technologies have been proposed with the aim of improving surgical results of KT and reducing the invasiveness of the procedure.[52–54]

However, a transplanted kidney may develop several subsequent problems, regardless of the surgical approach, potentially leading to permanent organ failure and graft loss.[54–56] Among these, urolithiasis represents a rare but potentially dangerous condition. Periodic clinical controls with ultrasound imaging in patients previously submitted to KT make this scenario uncommon but still experienceable.

The heterogeneous data from Literature make the assessment of the incidence of this condition hard to define, ranging from 0.1%[14] to 6.3% of Motayne et al.[9] This difference in incidence and time of de novo stones detection may be due to different follow-up protocols among Centers, Countries and Decades. In fact, the use of non-contrast CT scan changed the capability of early detection of intrarenal stones over the X-ray. In addition, changes in medical treatments for the modulation of the immune response against the graft was thought to be potentially responsible for the difference in lithiasis incidence in KT recipients.[57]

Regarding the stone composition, it should be underlined that patients submitted to KT are chronically exposed to immunemodulating medications which may cause metabolic alterations in human body. Ciclosporine A and glucocorticoids may induce hyperuricemia, making those patients at an increased risk of uric acid stones formation.[21] In fact, several studies, including those published by Motayne et al.[9] and Doehn et al.[20] reported an incidence of uric acid stones almost matching Calcium Oxalate in up to about 30% of the cases,[39] which is the most frequent composition observed in the non-transplanted population. In the other cohorts, Calcium Oxalate remains the main chemical composition of urinary stones, as reported by Klingler et al.[26] with a prevalence of 58% in a cohort of 19 patients. Other composition of lithiasis, such as struvite or infected stones, were found to be less prevalent.

In the majority of the cases, intrarenal lithiasis was observed. In fact, thanks to standardized follow-up programs providing periodic US, a prompt diagnosis is usually done. Differently from another SR published in 2022,[3] we decided to include patients with ureteral lithiasis since, surprisingly, ureteral stones are not a rare finding, as was reported by Emiliani et al. who observed 59% (30/51 patients) of ureteral lithiasis. Colic pain may miss in the allograft due to iatrogenic denervation, making this pathology devious and potentially much more dangerous than in a normal kidney because of the high risk of being unrecognized in time for prompt treatment.

Regarding treatment strategies, in most of the studies included in this revision, active treatment was chosen in consideration of the particular population investigated. Unfortunately, in several studies, we do not have data about the results of each treatment performed in terms of SFR. However, positive results are generally described for each treatment strategy, from endoscopic to open surgery, as it was reported by Emiliani et al. with a stone free rate of 100% (9/9 patients) for patients treated with ureteroscopy and 91% (20/22 patients) for those treated with ESWL[21] or 84% (21/25 patients) after ureteroscopy in the manuscript published by Brancherau et al.[38]

At this point, attention should be paid to the invasiveness and possible complications of each procedure, considering a different endoscopic/surgical anatomy in a transplanted kidney with its consequent challenges, especially in case of a surgeon without a high experience in this field. Even if the open surgical approach provided optimal results in terms of SFR after treatment in sporadic cases, as described by Li et al.[45] and Emiliani et al.,[21] the percutaneous or combined endoscopic/percutaneous approach represent an optimum compromise for the treatment of large intrarenal stones, as it was reported in a study on 95 patients with 9/10 (90%) patients free from lithiasis after percutaneous treatment.[38]

Finally, complications are just round the corner in previously transplanted patients as in the standard population. Lithiasis recurrence should not be considered a surgical failure but a pitfall to be investigated during follow-up. Sepsis, strictures, fistulas and so on are fearsome but fortunately rare occurrences. Urinary tract infections (IVU) were showed often complicated postoperative course, as described by Khositseth in 2004 with 40% of IVU, especially in an immunocompromised patient due to the risk of life-threatening sepsis.

Conclusions

Despite lithiasis in KT recipients being a rare condition, it represents a challenging disease both for diagnosis and treatment reasons. Timely diagnosis is essential since lithiasis in KT recipients may potentially compromise organ function. Each treatment option seems to provide positive results in terms of stone-free rate, laying the surgeon the choice of a more or less invasive treatment considering the different anatomy of the graft and related complications.

Conflicts of interest

The authors declare that they have no conflicts of interest.

References

1. Harper JM, Samuell CT, Hallson PC, Wood SM, Mansell MA. Risk factors for calculus formation in patients with renal transplants. Br J Urol. 1994;74:147–50, http://dx.doi.org/10.1111/j.1464-410x.1994.tb16576.x.
2. Moein M, Vlassis IM, Kim L, Hanlon M, Saidi R. Early readmissions post kidney transplantation: lessons learned. Actas Urol Esp (Engl Ed). 2023;47:382–9, http://dx.doi.org/10.1016/j.acuroe.2023.03.001.
3. Boissier R, Rodriguez-Faba O, Zakri RH, Hevia V, Budde K, Figueiredo A, et al. Evaluation of the effectiveness of interventions on nephrolithiasis in transplanted kidney. Eur Urol Focus. 2022;9:491–9, http://dx.doi.org/10.1016/j.euf.2022.11.019.
4. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71, http://dx.doi.org/10.1136/bmj.n71.
5. Wolff RF, Moons KGM, Riley R, Whiting PF, Westwood M, Collins GS, et al. PROBAST: a tool to assess the risk of bias and applicability of prediction model studies. Ann Intern Med. 2019;170:170, http://dx.doi.org/10.7326/M18-1376.
6. Gerber RC, Best SL, Hedican SP, Nakada SY. Flexible ureteroscopy as the new standard for the management of renal transplant urolithiasis <15 mm: a single-center experience. J Endourol. 2021;35:1443–7, http://dx.doi.org/10.1089/end.2020.0473.
7. Hayes JM, Streem SB, Graneto D, Hodge EE, Steinmuller DR, Novick AC. Renal transplant calculi. A reevaluation of risks and management. Transplantation. 1989;47:949–52, http://dx.doi.org/10.1097/00007890-198906000-00006.
8. Khositseth S, Gillingham KJ, Cook ME, Chavers BM. Urolithiasis after kidney transplantation in pediatric recipients: a single center report. Transplantation. 2004;78:1319–23, http://dx.doi.org/10.1097/01.tp.0000139543.56886.de.
9. Motayne GG, Jindal SL, Irvine AH, Abele RP. Calculus formation in renal transplant patients. J Urol. 1984;132:448–9, http://dx.doi.org/10.1016/s0022-5347(17)49686-8.
10. Yuan H, Yang D, Cui Y, Men C, Gao Z, Shi L, et al. Minimally invasive treatment of renal transplant nephrolithiasis. World J Urol. 2015;33:2079–85, http://dx.doi.org/10.1007/s00345-015-1549-9.
11. Buresley S, Samhan M, Moniri S, Codaj J, Al-Mousawi M. Postrenal transplantation urologic complications. Transplant Proc. 2008;40:2345–6, http://dx.doi.org/10.1016/j.transproceed.2008.06.036.
12. Bolen E, Stern K, Humphreys M, Brady A, Leavitt T, Zhang N, et al. Urine metabolic risk factors and outcomes of patients with kidney transplant nephrolithiasis. Clin Kidney J. 2022;15:500–6, http://dx.doi.org/10.1093/ckj/sfab208.
13. Benoit G, Blanchet P, Eschwege P, Jardin A, Charpentier B. Occurrence and treatment of kidney graft lithiasis in a series of 1500 patients. Clin Transplant. 1996;10:176–80.
14. Abbott KC, Schenkman N, Swanson SJ, Agodoa LY. Hospitalized nephrolithiasis after renal transplantation in the United States. Am J Transplant. 2003;3:465–70, http://dx.doi.org/10.1034/j.1600-6143.2003.00080.x.
15. Basiri A, Nikoobakht MR, Simforoosh N, Hosseini Moghaddam SMM. Ureteroscopic management of urological complications after renal transplantation. Scand J Urol Nephrol. 2006;40:53–6, http://dx.doi.org/10.1080/00365590510007838.
16. Challacombe B, Dasgupta P, Tiptaft R, Glass J, Koffman G, Goldsmith D, et al. Multimodal management of urolithiasis in renal transplantation. BJU Int. 2005;96:385–9, http://dx.doi.org/10.1111/j.1464-410X.2005.05636.x.
17. Cho DK, Zackson DA, Cheigh J, Stubenbord WT, Stenzel KH. Urinary calculi in renal transplant recipients. Transplantation. 1988;45:899–902, http://dx.doi.org/10.1097/00007890-198805000-00011.
18. Cicerello E, Merlo F, Mangano M, Cova G, Maccatrozzo L. Urolithiasis in renal transplantation: diagnosis and management. Arch Ital Urol Androl. 2014;86:257–60, http://dx.doi.org/10.4081/aiua.2014.4.257.

19. Del Pizzo JJ, Jacobs SC, Sklar GN. Ureteroscopic evaluation in renal transplant recipients. J Endourol. 1998;12:135–8, http://dx.doi.org/10.1089/end.1998.12.135.
20. Doehn C, Fornara P, Tiemer C, Fricke L, Jocham D. Renal transplant lithiasis. Transplant Proc. 2002;34:2222–3, http://dx.doi.org/10.1016/s0041-1345(02)03211-6.
21. Emiliani E, Subiela JD, Regis F, Angerri O, Palou J. Over 30-yr experience on the management of graft stones after renal transplantation. Eur Urol Focus. 2018;4:169–74, http://dx.doi.org/10.1016/j.euf.2018.06.007.
22. Ferreira Cassini M, Cologna AJ, Ferreira Andrade M, Lima GJ, Medeiros Albuquerque U, Pereira Martins AC, et al. Lithiasis in 1,313 kidney transplants: incidence, diagnosis, and management. Transplant Proc. 2012;44:2373–5, http://dx.doi.org/10.1016/j.transproceed.2012.07.052.
23. Friedersdorff F, El-Bandar N, Busch J, Erber B, Miller K, Fuller TF, et al. Urolithiasis in renal allografts: complications and outcomes. Exp Clin Transplant. 2017;15:164–70, http://dx.doi.org/10.6002/ect.2016.0040.
24. Harraz AM, Zahran MH, Kamal AI, El-Hefnawy AS, Osman Y, Soliman SA, et al. Contemporary management of renal transplant recipients with de novo urolithiasis: a single institution experience and review of the literature. Exp Clin Transplant. 2017;15:277–81.
25. Kim H, Cheigh JS, Ham HW. Urinary stones following renal transplantation. Korean J Intern Med. 2001;16:118–22, http://dx.doi.org/10.3904/kjim.2001.16.2.118.
26. Klingler HC, Kramer G, Lodde M, Marberger M. Urolithiasis in allograft kidneys. Urology. 2002;59:344–8, http://dx.doi.org/10.1016/s0090-4295(01)01575-8.
27. Mahdavi R, Tavakkoli M, Taghavi R, Ghoreifi A. Minimally invasive procedures for treatment of urolithiasis in transplanted kidneys. Exp Clin Transplant. 2014;12:200–4.
28. Mamarelis G, Vernadakis S, Moris D, Altanis N, Perdikouli M, Stravodimos K, et al. Lithiasis of the renal allograft, a rare urological complication following renal transplantation: a single-center experience of 2,045 renal transplantations. Transplant Proc. 2014;46:3203–5, http://dx.doi.org/10.1016/j.transproceed.2014.09.166.
29. Montanari E, Zanetti G. Management of urolithiasis in renal transplantation. Arch Ital Urol Androl. 2009;81:175–81.
30. Rezaee-Zavareh MS, Ajudani R, Ramezani Binabaj M, Heydari F, Einollahi B. Kidney allograft stone after kidney transplantation and its association with graft survival. Int J Organ Transplant Med. 2015;6:114–8.
31. Rhee BK, Bretan PN, Stoller ML. Urolithiasis in renal and combined pancreas/renal transplant recipients. J Urol. 1999;161:1458–62.
32. Sarier M, Duman I, Yuksel Y, Tekin S, Demir M, Arslan F, et al. Results of minimally invasive surgical treatment of allograft lithiasis in live-donor renal transplant recipients: a single-center experience of 3758 renal transplantations. Urolithiasis. 2019;47:273–8, http://dx.doi.org/10.1007/s00240-018-1051-0.
33. Sevinc C, Balaban M, Ozkaptan O, Karadeniz T. Flexible ureterorenoscopy and laser lithotripsy for the treatment of allograft kidney lithiasis. Transpl Proc. 2015;47, http://dx.doi.org/10.1016/j.transproceed.2015.06.020.
34. Shoskes DA, Hanbury D, Cranston D, Morris PJ. Urological complications in 1,000 consecutive renal transplant recipients. J Urol. 1995;153:18–21, http://dx.doi.org/10.1097/00005392-199501000-00008.
35. Streeter EH, Little DM, Cranston DW, Morris PJ. The urological complications of renal transplantation: a series of 1535 patients. BJU Int. 2002;90:627–34, http://dx.doi.org/10.1046/j.1464-410x.2002.03004.x.
36. Verrier C, Bessede T, Hajj P, Aoubid L, Eschwege P, Benoit G. Decrease in and management of urolithiasis after kidney transplantation. J Urol. 2012;187:1651–5, http://dx.doi.org/10.1016/j.juro.2011.12.060.
37. Yiğit B, Aydin C, Titiz I, Berber I, Sinanoğlu O, Altaca G. Stone disease in kidney transplantation. Transplant Proc. 2004;36:187–9, http://dx.doi.org/10.1016/j.transproceed.2003.11.063.
38. Branchereau J, Timsit MO, Neuzillet Y, Bessède T, Thuret R, Gigante M, et al. Management of renal transplant urolithiasis: a multicentre study by the French Urology Association Transplantation Committee. World J Urol. 2018;36:105–9, http://dx.doi.org/10.1007/s00345-017-2103-8.
39. He Z, Li X, Chen L, Zeng G, Yuan J. Minimally invasive percutaneous nephrolithotomy for upper urinary tract calculi in transplanted kidneys. BJU Int. 2007;99:1467–71, http://dx.doi.org/10.1111/j.1464-410X.2007.06768.x.
40. Hyams E, Marien T, Bruhn A, Quirouet A, Andonian S, Shah O, et al. Ureteroscopy for transplant lithiasis. J Endourol. 2012;26:819–22, http://dx.doi.org/10.1089/end.2011.0495.
41. Krambeck AE, Leroy AJ, Patterson DE, Gettman MT. Percutaneous nephrolithotomy success in the transplant kidney. J Urol. 2008;180:2545–9, http://dx.doi.org/10.1016/j.juro.2008.08.032.
42. Martin G, Sundaram CP, Sharfuddin A, Govani M. Asymptomatic urolithiasis in living donor transplant kidneys: initial results. Urology. 2007;70:2–5, http://dx.doi.org/10.1016/j.urology.2007.01.105, discussion 5–6.
43. Oliveira M, Branco F, Martins L, Lima E. Percutaneous nephrolithotomy in renal transplants: a safe approach with a high stone-free rate. Int Urol Nephrol. 2011;43:329–35, http://dx.doi.org/10.1007/s11255-010-9837-1.
44. Stravodimos KG, Adamis S, Tyritzis S, Georgios Z, Constantinides CA. Renal transplant lithiasis: analysis of our series and review of the literature. J Endourol. 2012;26:38–44, http://dx.doi.org/10.1089/end.2011.0049.
45. Li S, Wang Q, Chen W. Treatment of urinary lithiasis following kidney transplantation with extracorporeal shock-wave lithotripsy. Chin Med J (Engl). 2011;124:1431–4.
46. Wolfe RA, Ashby VB, Milford EL, Ojo AO, Ettenger RE, Agodoa LY, et al. Comparison of mortality in all patients on dialysis, patients on dialysis awaiting transplantation, and recipients of a first cadaveric transplant. N Engl J Med. 1999;341:1725–30, http://dx.doi.org/10.1056/NEJM199912023412303.
47. Campi R, Pecoraro A, Sessa F, Vignolini G, Caroti L, Lazzeri C, et al. Outcomes of kidney transplantation from uncontrolled donors after circulatory death vs. expanded-criteria or standard-criteria donors after brain death at an Italian Academic Center: a prospective observational study. Minerva Urol Nephrol. 2023;75:329–42, http://dx.doi.org/10.23736/S2724-6051.23.05098-X.
48. Territo A, Diana P, Gaya JM, Gallioli A, Piana A, Breda A. Robot-assisted kidney transplantation: state of art. Arch Esp Urol. 2021;74:970–8.
49. Breda A, Diana P, Territo A, Gallioli A, Piana A, Gaya JM, et al. Intracorporeal Versus extracorporeal robot-assisted kidney autotransplantation: experience of the ERUS RAKT Working Group. Eur Urol. 2021;81:168–75, http://dx.doi.org/10.1016/j.eururo.2021.07.023.
50. Territo A, Bajeot AS, Mesnard B, Campi R, Pecoraro A, Hevia V, et al. Open versus robotic-assisted kidney transplantation: a systematic review by the European Association of Urology (EAU) — Young Academic Urologists (YAU) Kidney Transplant Working Group. Actas Urol Esp (Engl Ed). 2023, http://dx.doi.org/10.1016/j.acuroe.2023.03.003. Mar 24:S2173-5786(23)00039-2. English, Spanish. Epub ahead of print. PMID: 36965855.

51. Andras I, Pecoraro A, Piana A, Prudhomme T, Campi R, Hevia V, et al. Aims and limits to compare open vs. robotic assisted kidney transplantation. Actas Urol Esp (Engl Ed). 2022;47:193–4, http://dx.doi.org/10.1016/j.acuroe.2022.11.003.
52. Piana A, Gallioli A, Amparore D, Diana P, Territo A, Campi R, et al. Three-dimensional augmented reality-guided robotic-assisted kidney transplantation: breaking the limit of atheromatic plaques. Eur Urol. 2022;82:419–26, http://dx.doi.org/10.1016/j.eururo.2022.07.003.
53. Territo A, Piana A, Fontana M, Diana P, Gallioli A, Gaya JM, et al. Step-by-step development of a cold ischemia device for open and robotic-assisted renal transplantation. Eur Urol. 2021;80:738–45, http://dx.doi.org/10.1016/j.eururo.2021.05.026.
54. Piana A, Breda A, Pecoraro A, Prudhomme T, Territo A. EAU — Young Academic Urologist (YAU) Working Group on Kidney Transplantion. Comment on: ''Surgeon preimplantation macroscopic graft appraisal improves risk stratification of deceased kidney donors: a prospective study.''. Minerva Urol Nephrol. 2022;74:805–6, http://dx.doi.org/10.23736/S2724-6051.22.05178-3.
55. Piana A, Andras I, Diana P, Verri P, Gallioli A, Campi R, et al. Small renal masses in kidney transplantation: overview of clinical impact and management in donors and recipients. Asian J Urol. 2022;9:208–14, http://dx.doi.org/10.1016/j.ajur.2022.06.001.
56. Greco F, Alba S, Fornara P, Mirone V. Renal transplantation: technical aspects, diagnosis and management of early and late urological complications. Panminerva Med. 2016;58:294–303.
57. Sohn DW, Kim SW, Hong CG, Yoon BI, Ha U-S, Cho Y-H. Risk factors of infectious complication after ureteroscopic procedures of the upper urinary tract. J Infect Chemother. 2013;19:1102–8, http://dx.doi.org/10.1007/s10156-013-0632-7.